
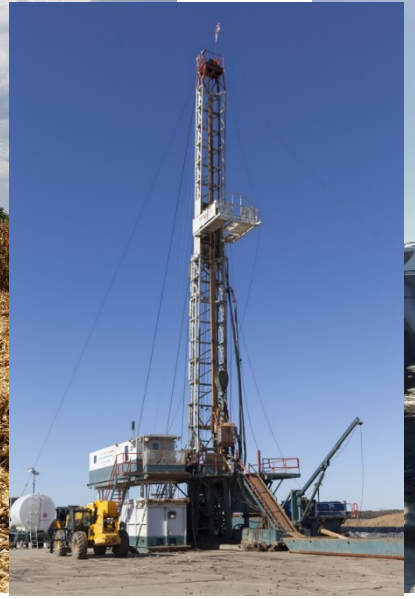


CarbonSAFE Illinois – Macon County

DE-FE0029381

Steve Whittaker

Addressing the Nation's Energy Needs Through Technology Innovation – 2019

Carbon Capture, Utilization, Storage, and Oil and Gas Technologies Integrated Review Meeting

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MGSC

U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

ADM

UW
Casper

PRAIRIE STATE
Generating Company

Projeo

TRIMERIC CORPORATION

GEOSTOCK
ENTREPOSE

IEc

Richland
COMMUNITY COLLEGE

Pacific Northwest
NATIONAL LABORATORY

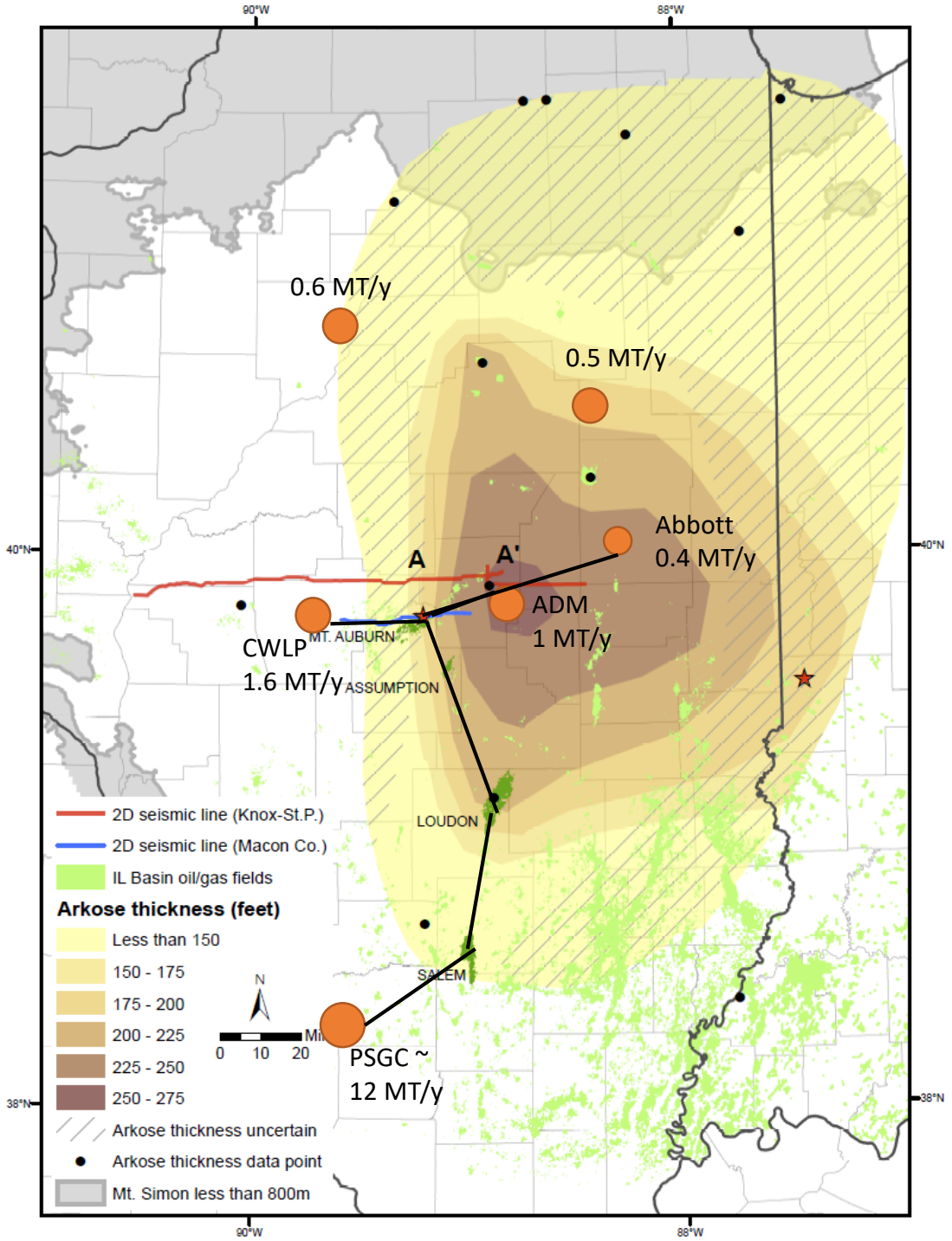
BYU
BRIGHAM YOUNG
UNIVERSITY

Presentation Outline

- Project Context
- Data Aquistion
- Reservoir Characterization
- Storage Feasibility

CarbonSAFE Illinois – Macon County CO_2 Sources

- 10's of MT/y CO_2
- Variety of industries
- Recent increased interest in storage
- Opportunity to greatly improve commercialization decisions by defining storage resource



Mt Simon Sandstone Storage Complex

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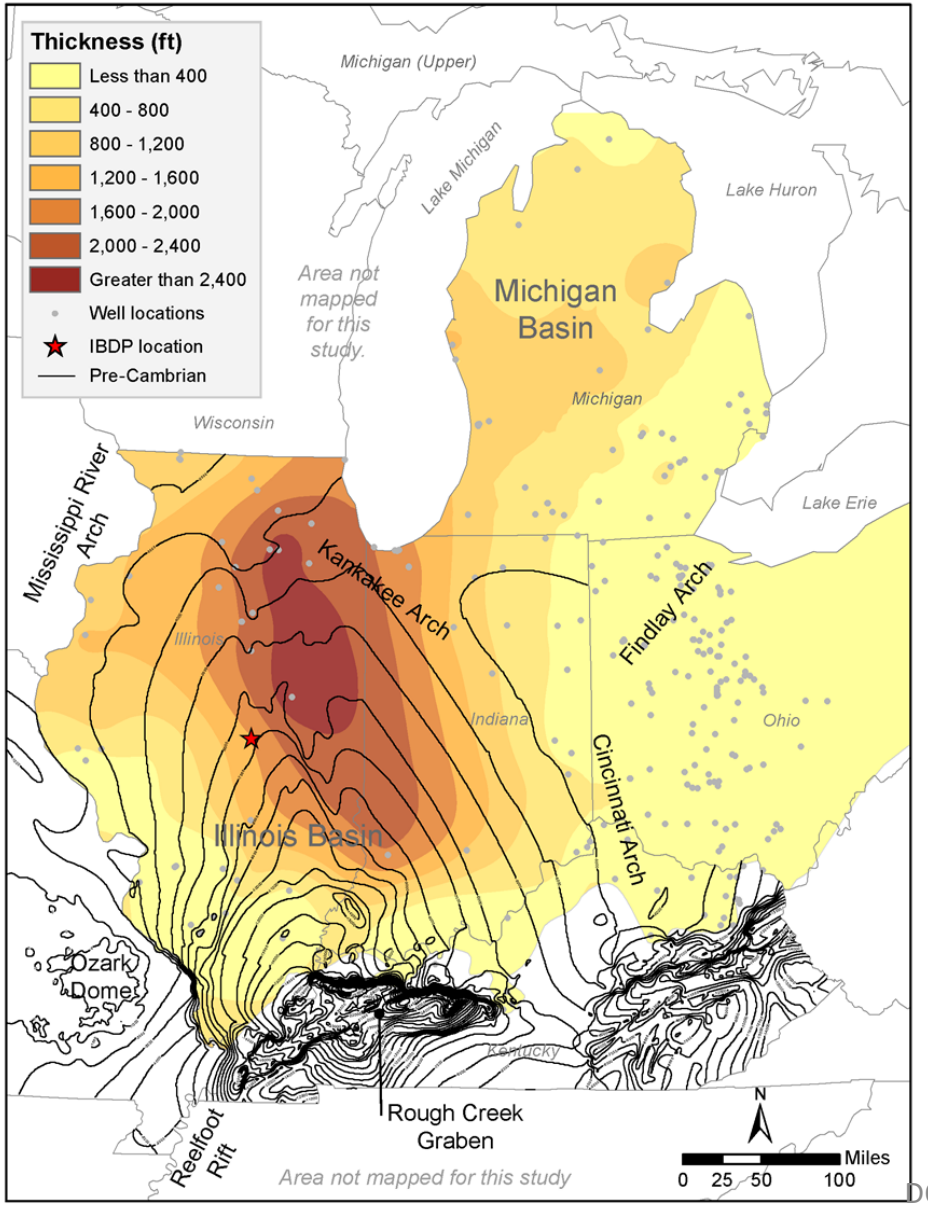


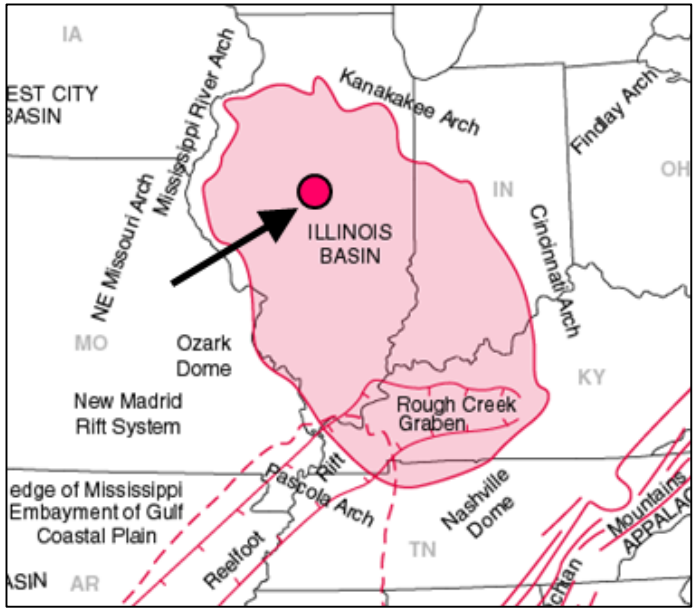
SYSTEM	GROUP	FORMATION	Storage Elements
Ordovician	Maquoketa	Brainard	Secondary Seal
		Ft. Atkinson	
		Scales	
	Galena	Kimmswick	
		Decorah	
	Plateville		
	Ancell	Joachim	
		St. Peter	Potential target
	Knox	Shakoppee	Secondary Seal/Reservoir
		New Richmond	
		Oneota	
		Gunter	
		Eminence	
		Potosi	Potential target
		Franconia	
Cambrian		Ironton-Galesville	
		Eau Claire	Primary Seal
		Mt. Simon	Target reservoir
Precambrian			

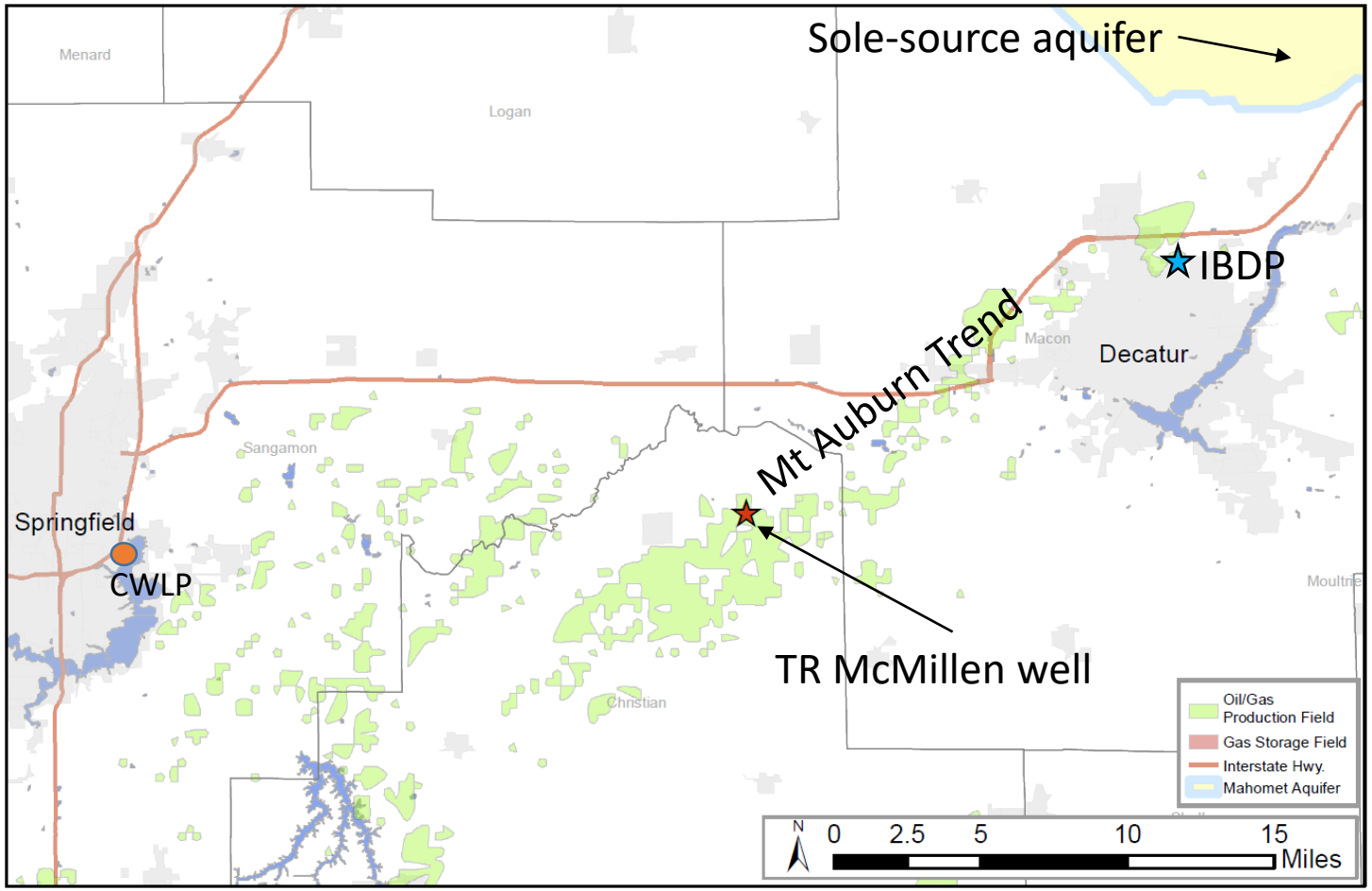
St. Peter-Knox Storage Complex

Mt. Simon Storage Complex

Cambro-Ordovician Storage Complex

CarbonSAFE Illinois – Macon County





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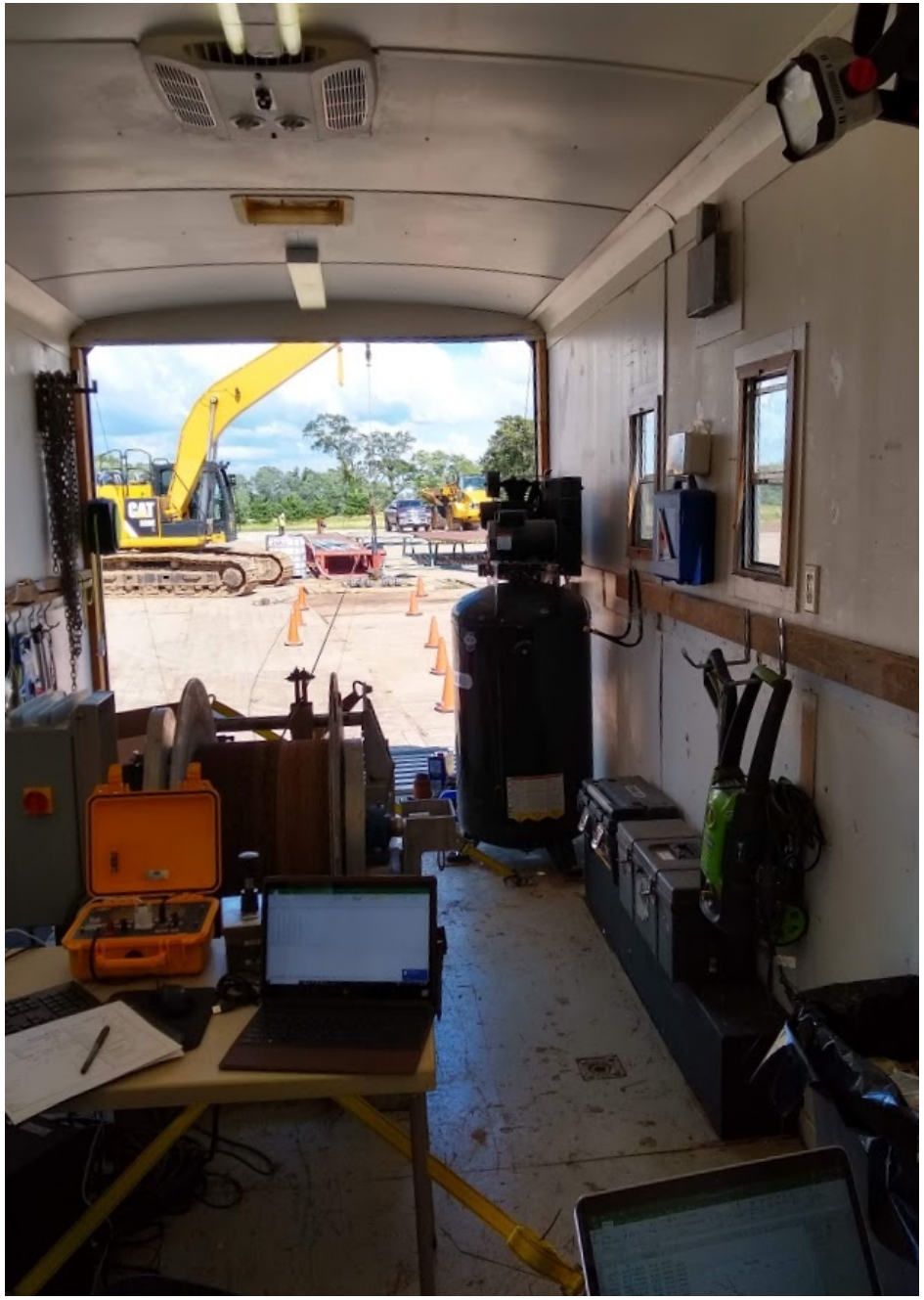
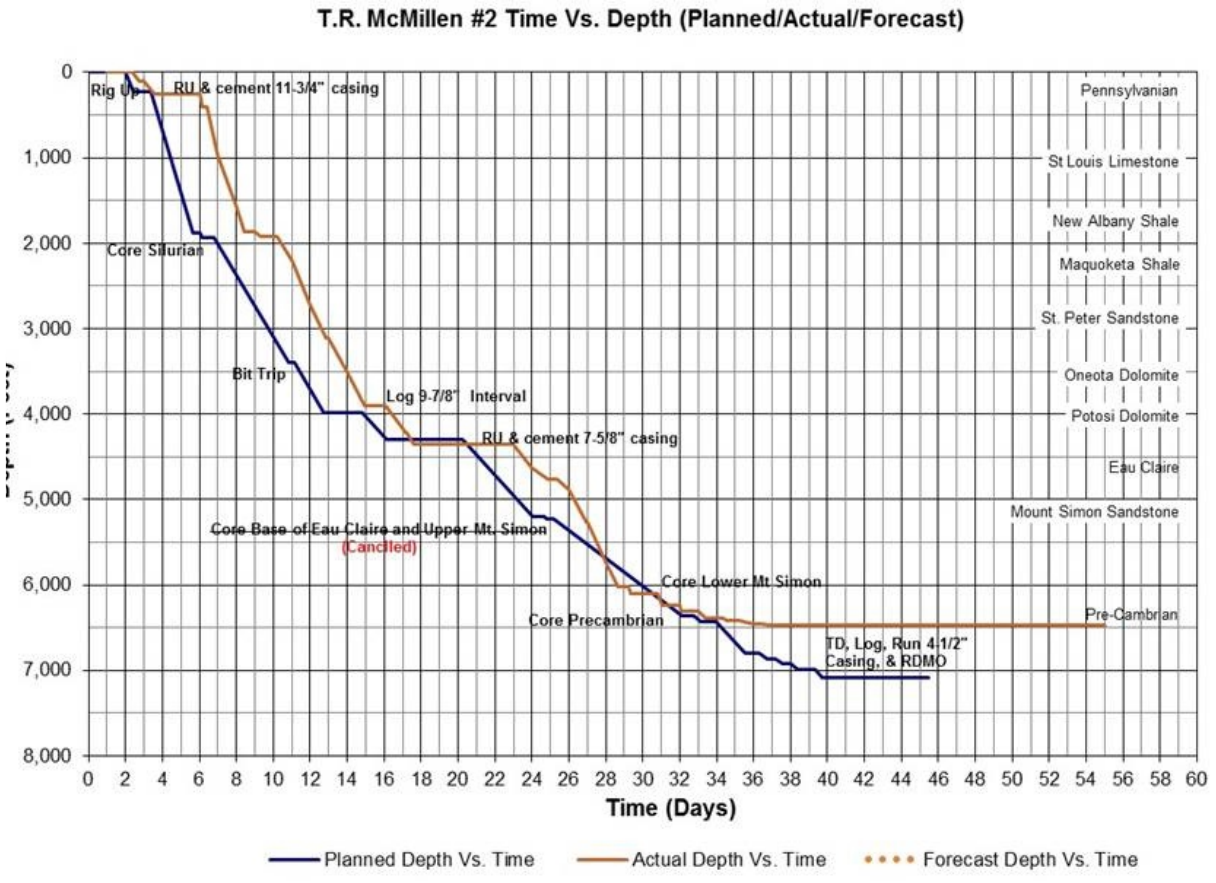
Data Acquisition

- Well drilled
- Full core, sidewall core, cuttings
- Petrography, XRD,CT scans
- Extensive suite of geophysical logs
- VSP (2D walkaway and 0 offset)
- 2D Seismic ~ 30 km
- Well testing – ongoing





Characterization Well: T.R.McMillen #2

Sample Collection: T.R.McMillen #2

- Drilling completed December 2, 2018
- TD at 6,469 ft
- 150 feet of 3.5 inch core:
  - Silurian 62 ft
  - Lower Mt Simon 61
  - Precambrian 27
- 109 rotary sidewall cores
- Extensive suite of geophysical logs

Lower Mt Simon Core: 6288-6294 ft

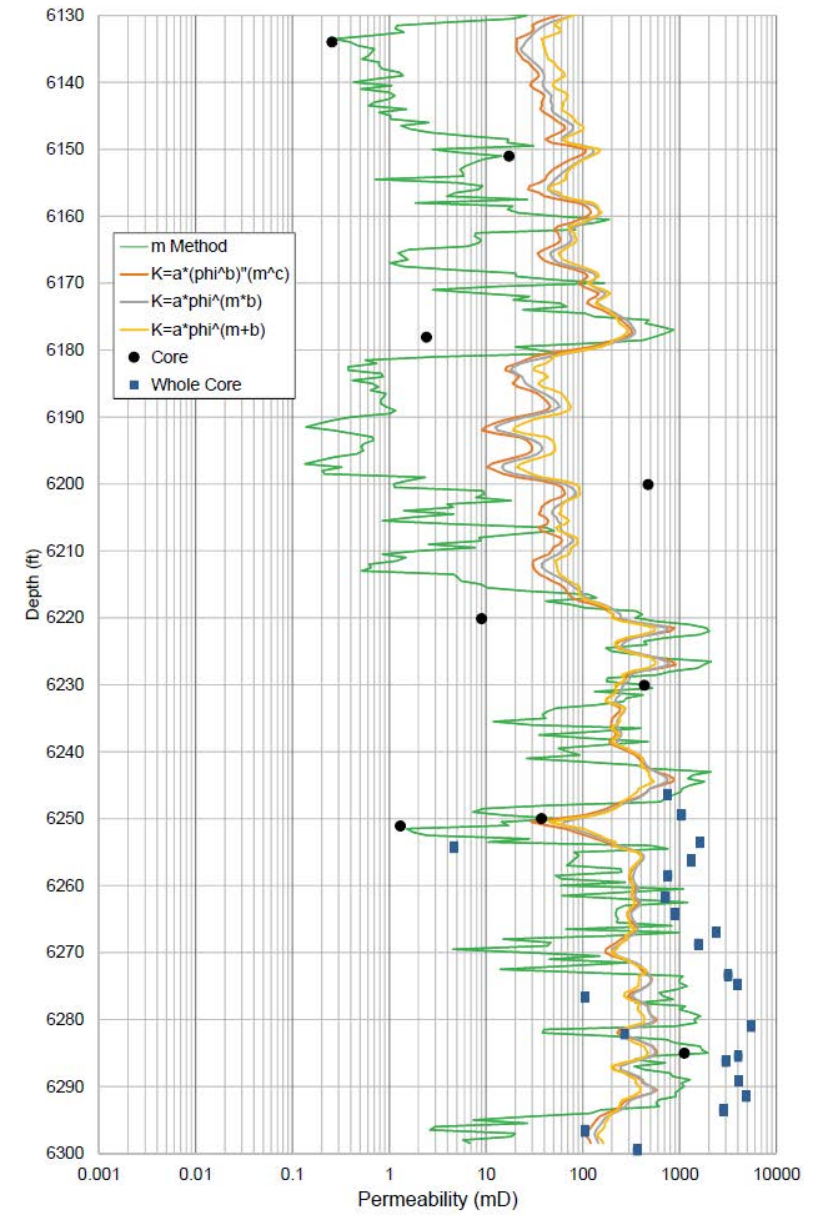
Lower Mt Simon Storage Complex

Porosity averages ~ 20%

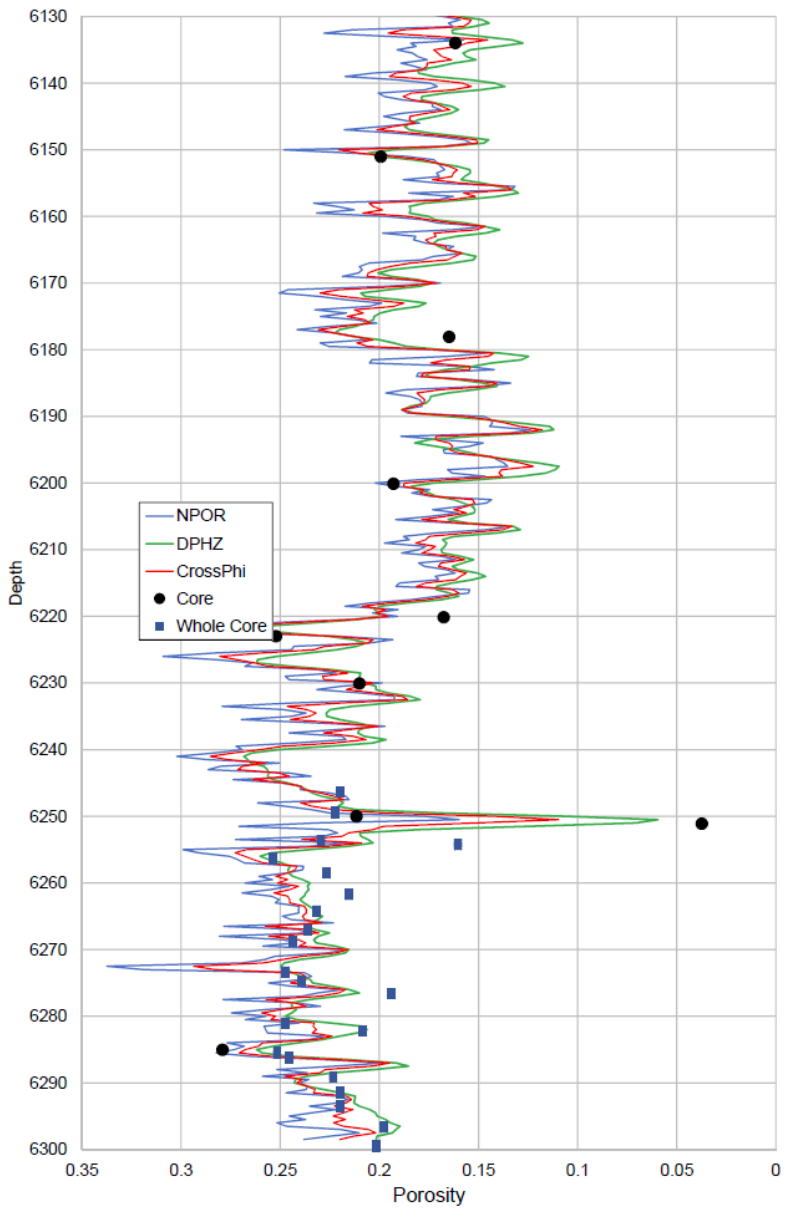
Permeability ca 100's of mD Side wall and whole core samples with Darcy permeability (up to 5.5)!

Preliminary simulation indicates CO_2 injection rates of 1.7 Mt/y with 15' perforation

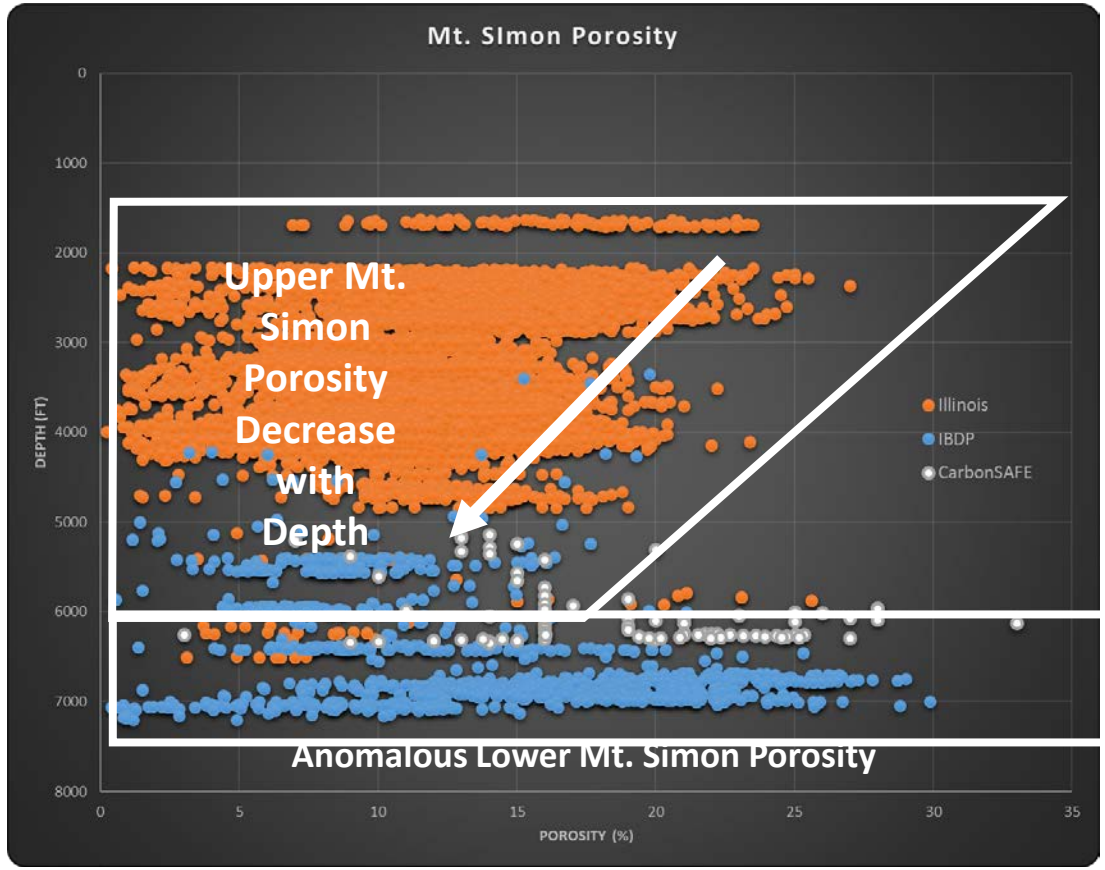
Permeability

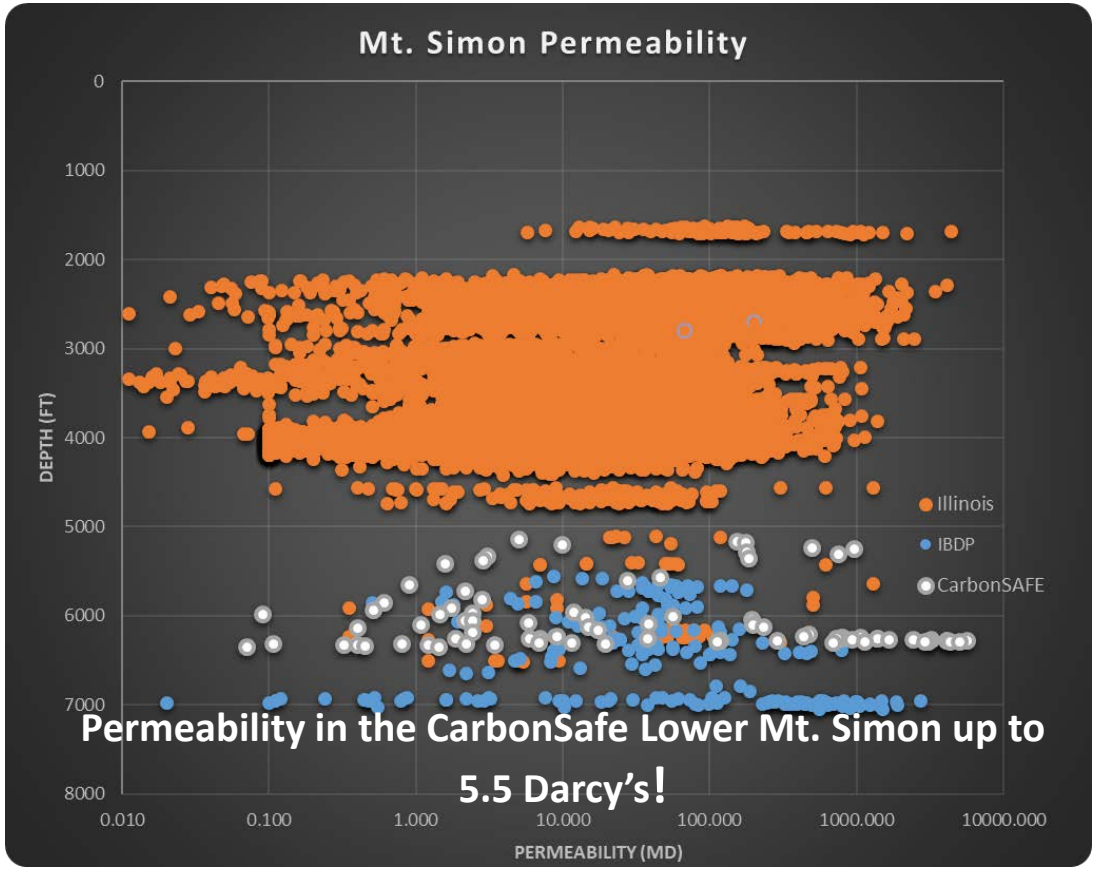


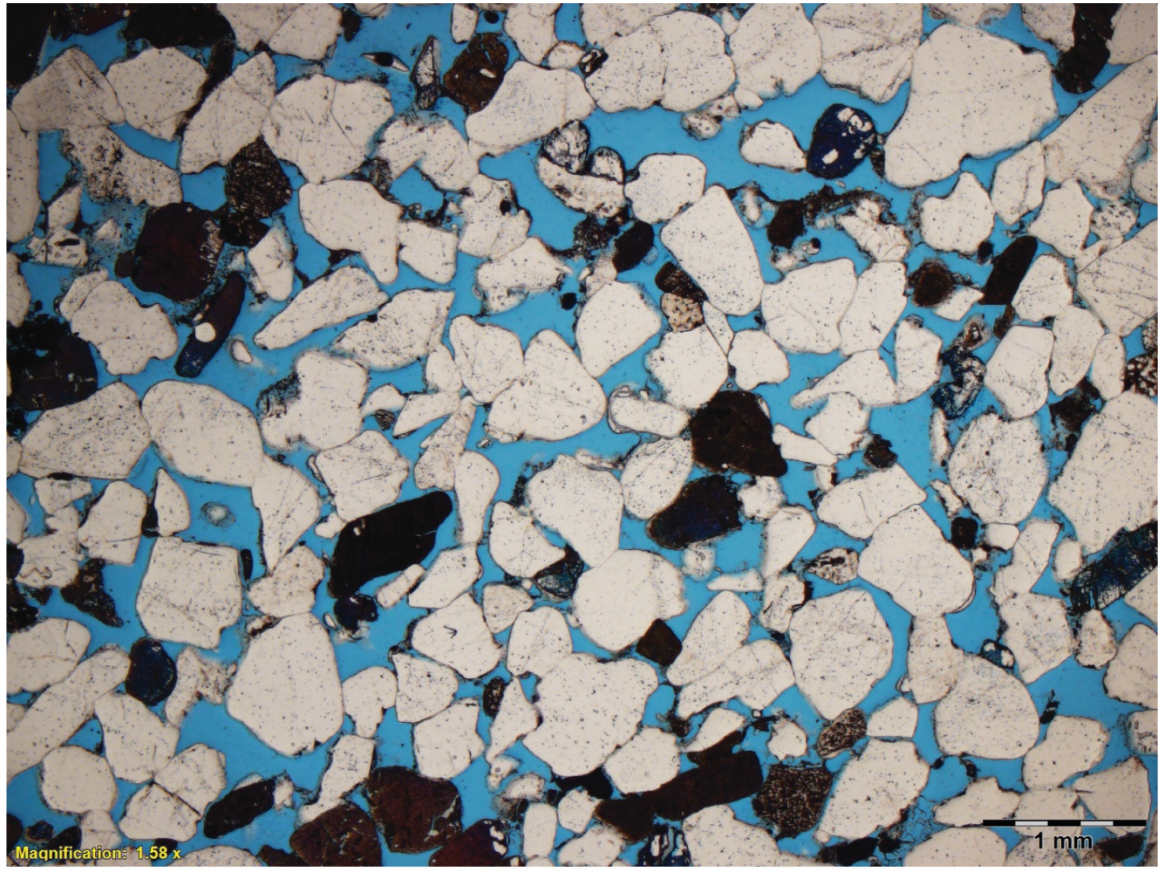
Porosity

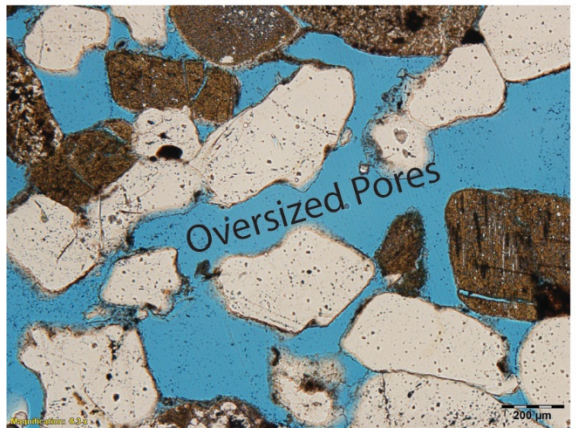


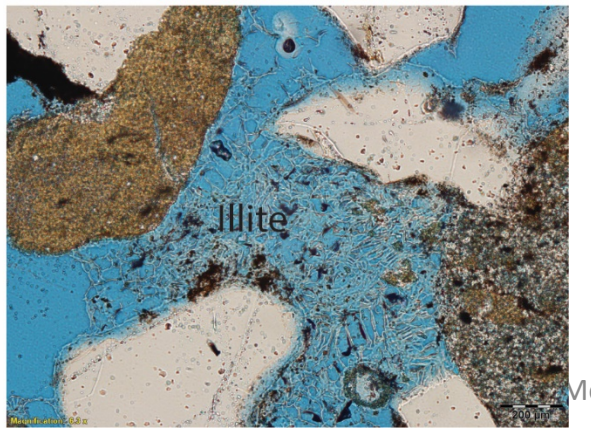
Depth trends not apparent in Lower Mt Simon







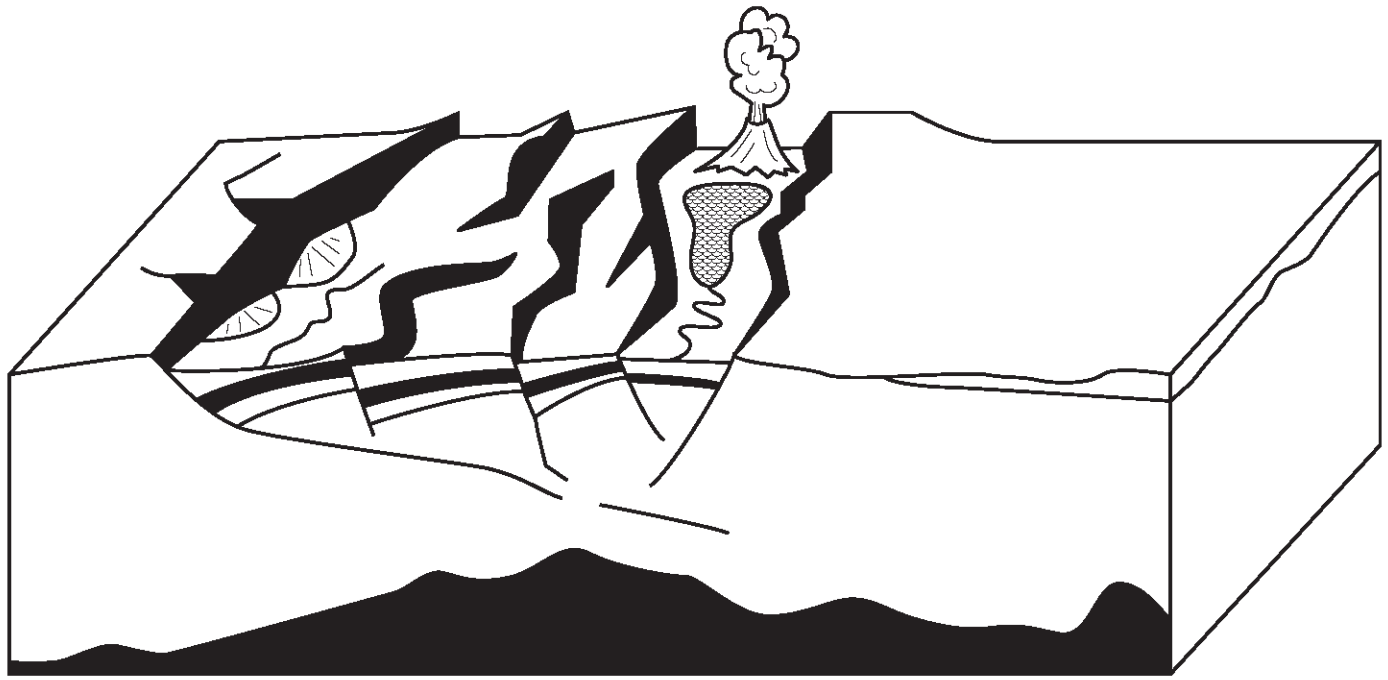




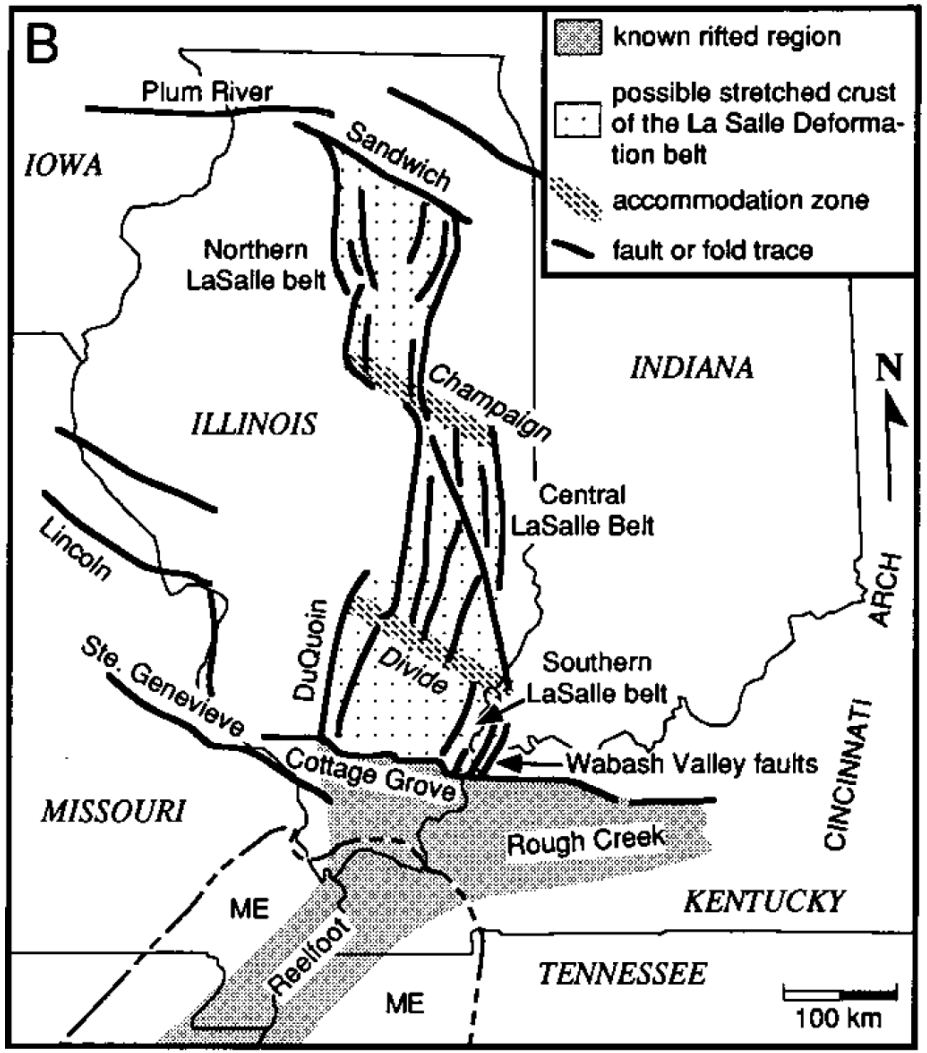
What makes the Lower Mt. Simon such a good reservoir?

- Detrital Source
- Depositional Environment
- Diagenesis

Rifting in Central Illinois

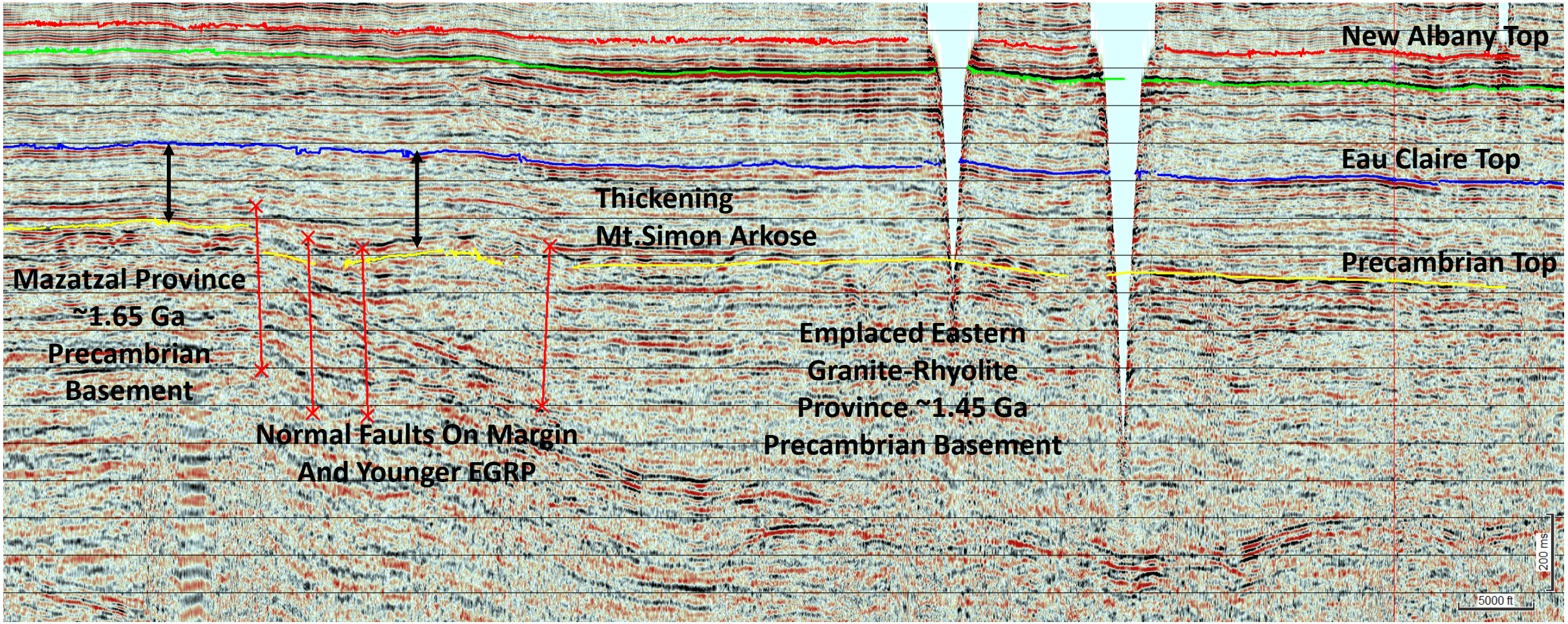


Modified from: Renaut & Ashley 2002

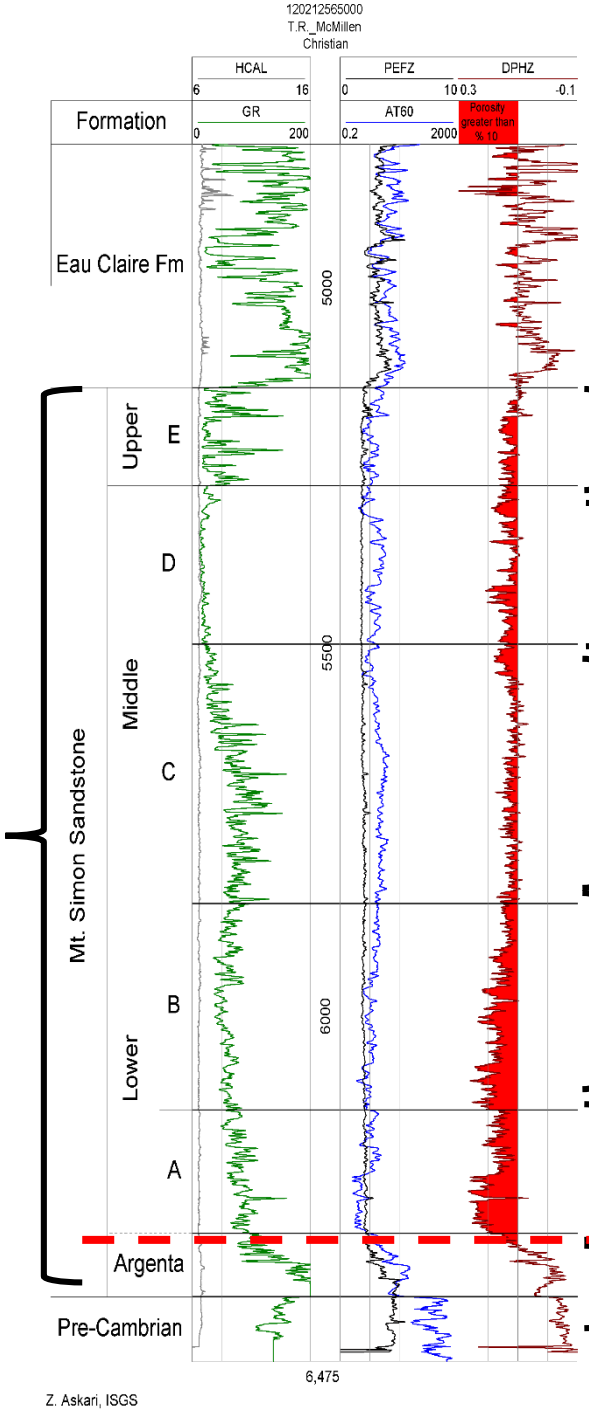


Marshak & Paulsen 1996

Crustal thinning, faulting, and development of localized depocenters during rifting. Precambrian highs are a local source of arkose.



T.R. McMillen #2
Mt. Simon Sandstone



Dominant Depositional Environment

Tidal Flat

Aeolian

Fluvial

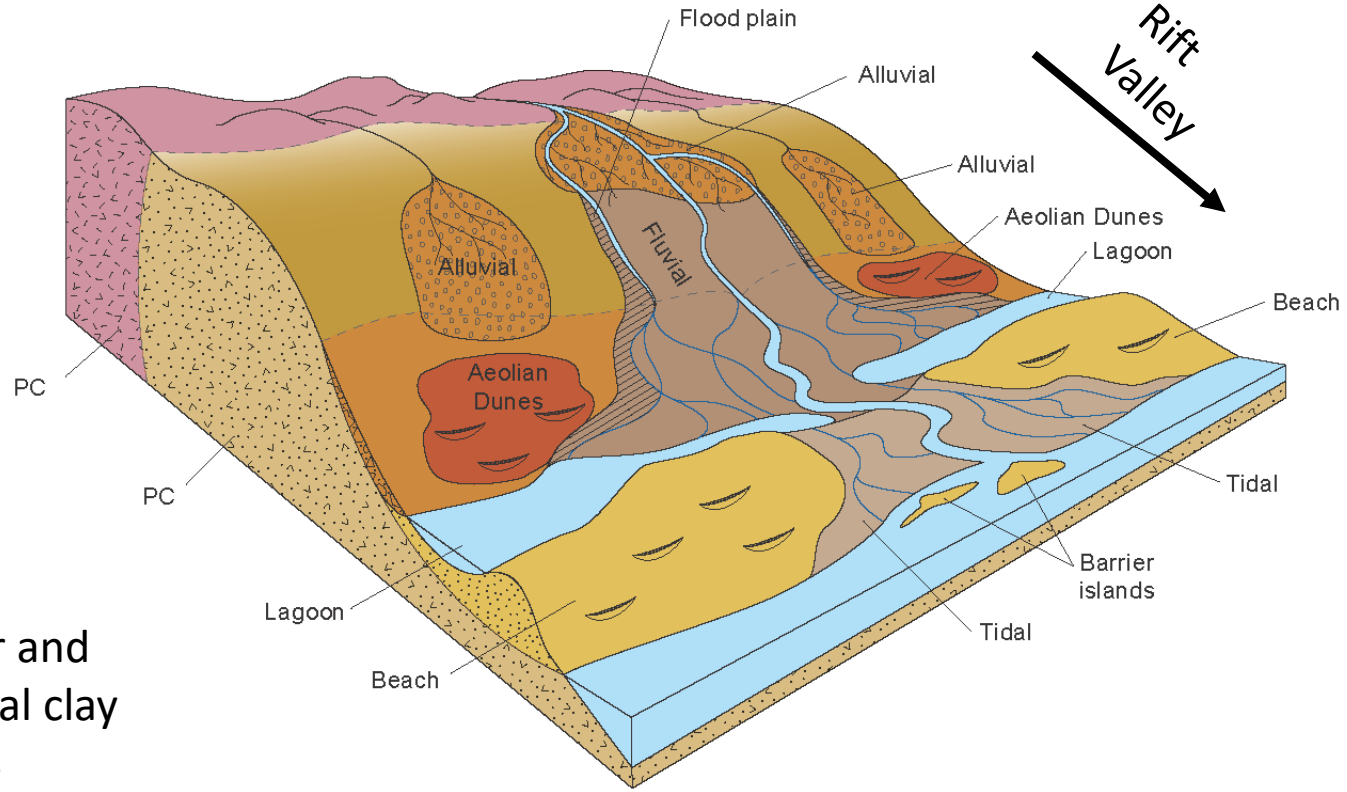
Aeolian

Fluvial/ Alluvial

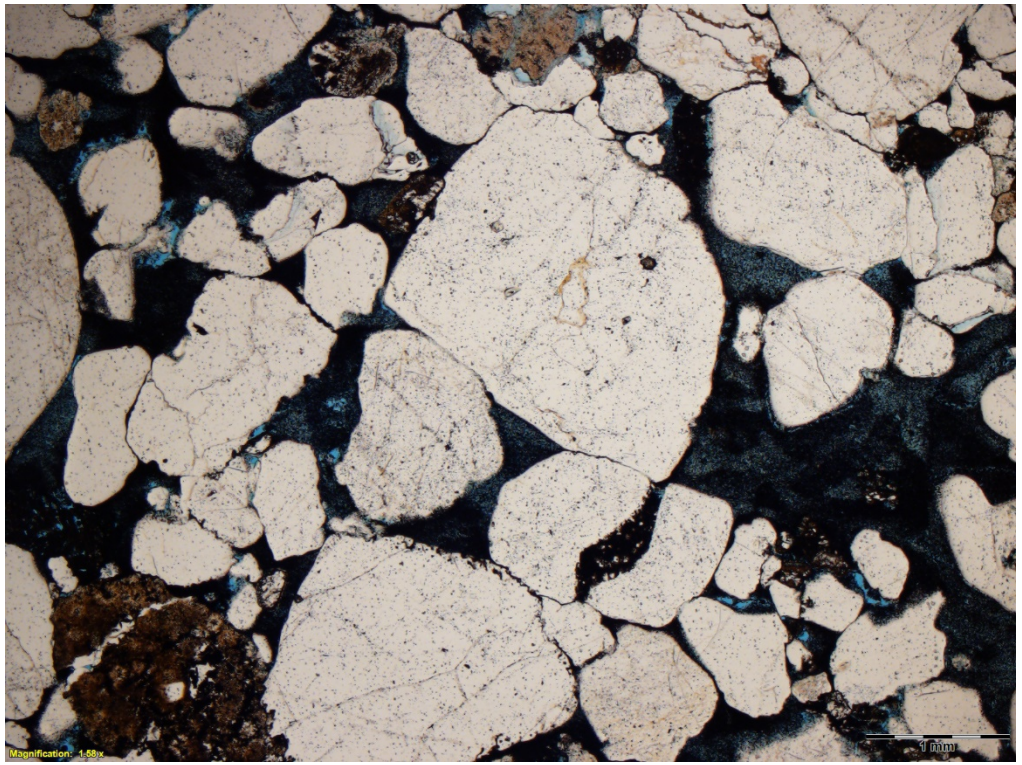
Feldspar and terrestrial clay coatings sourced from Precambrian highs

Unconformity

Rift Fan Delta

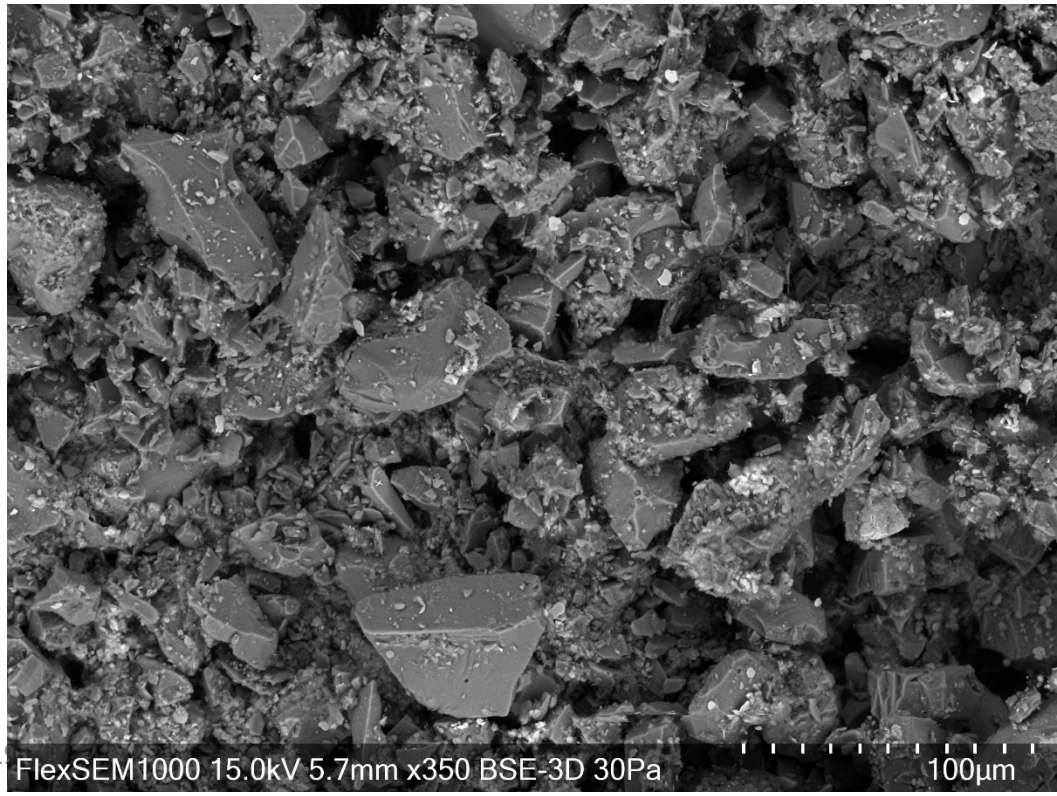


Rift Fan Delta Sediments (Argenta)

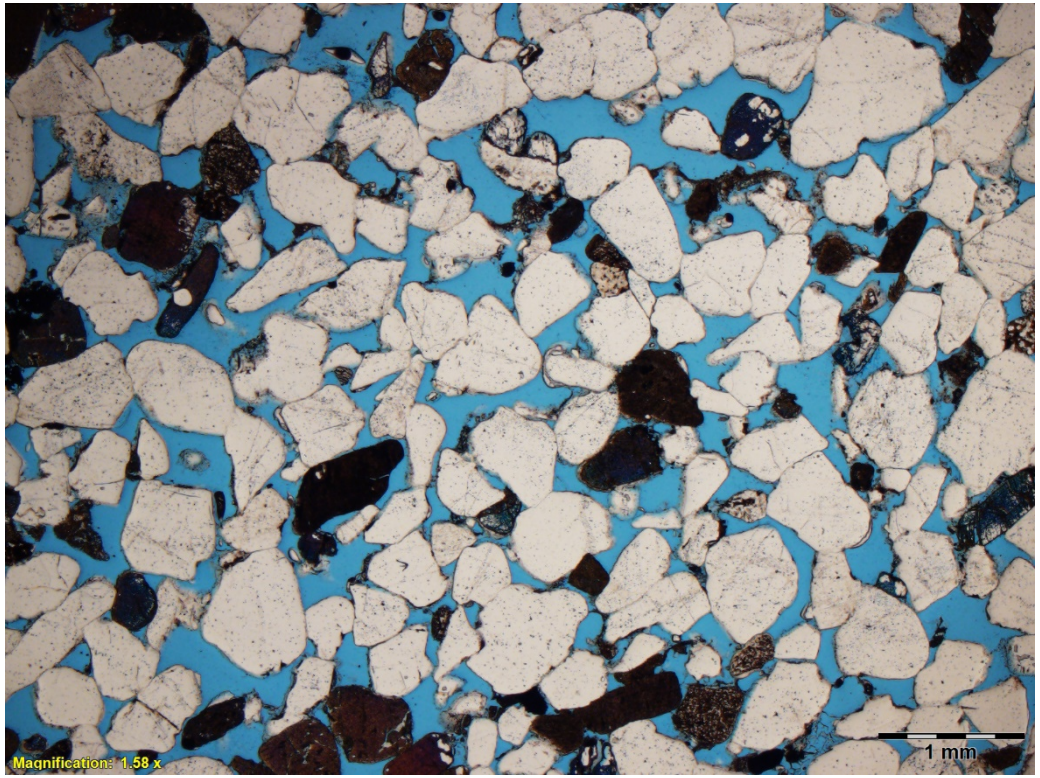


Poorly sorted grains with abundant pore filling clay

Highly angular immature detritus

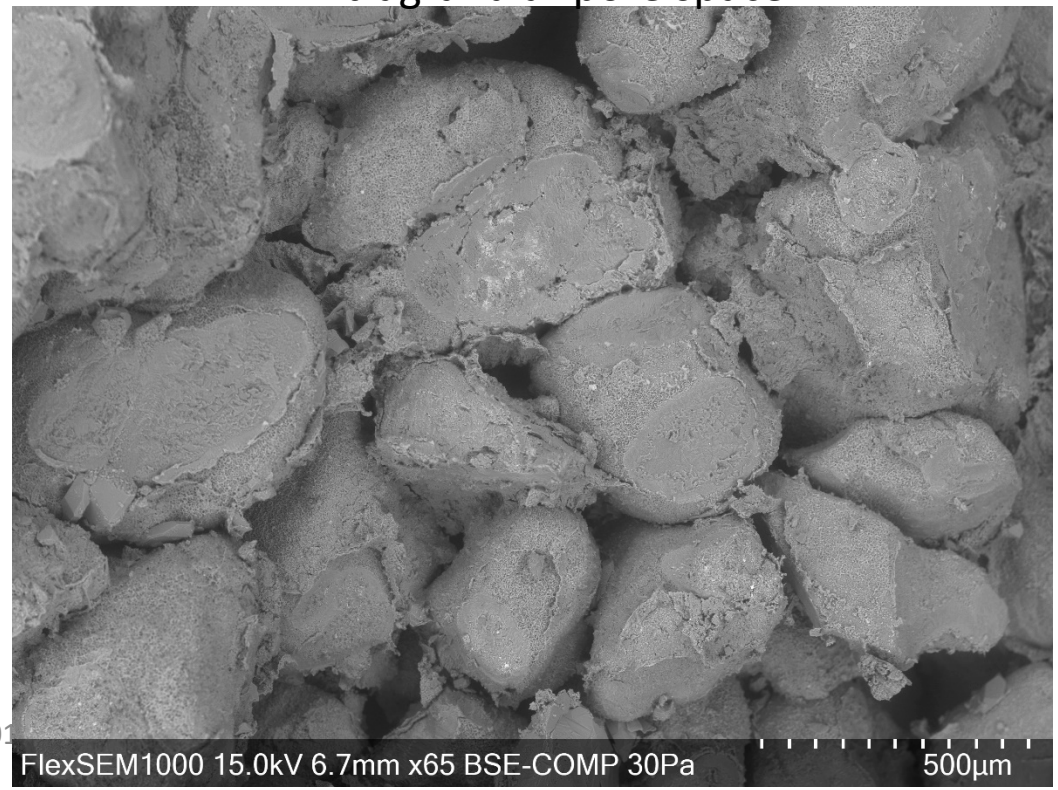


Alluvial-Fluvial-Eolian Near-shore (Lower Mt. Simon)

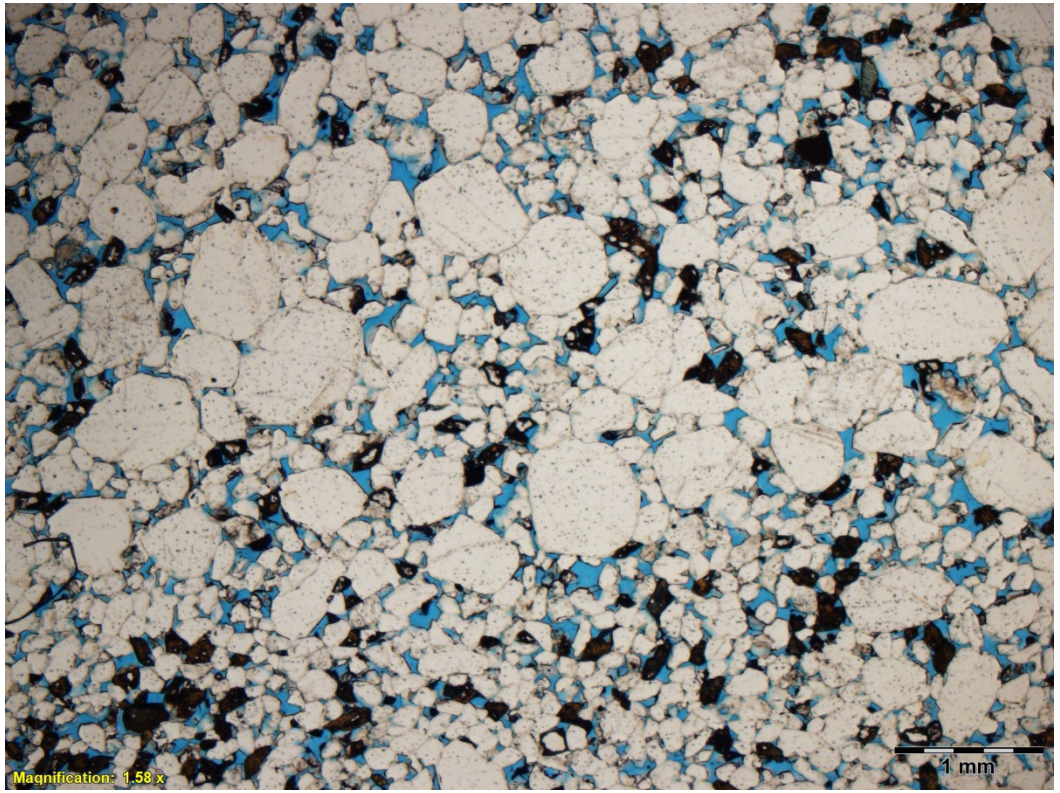


Moderately well sorted grains with open enlarged pores

Well rounded grains with abundant intragranular pore space

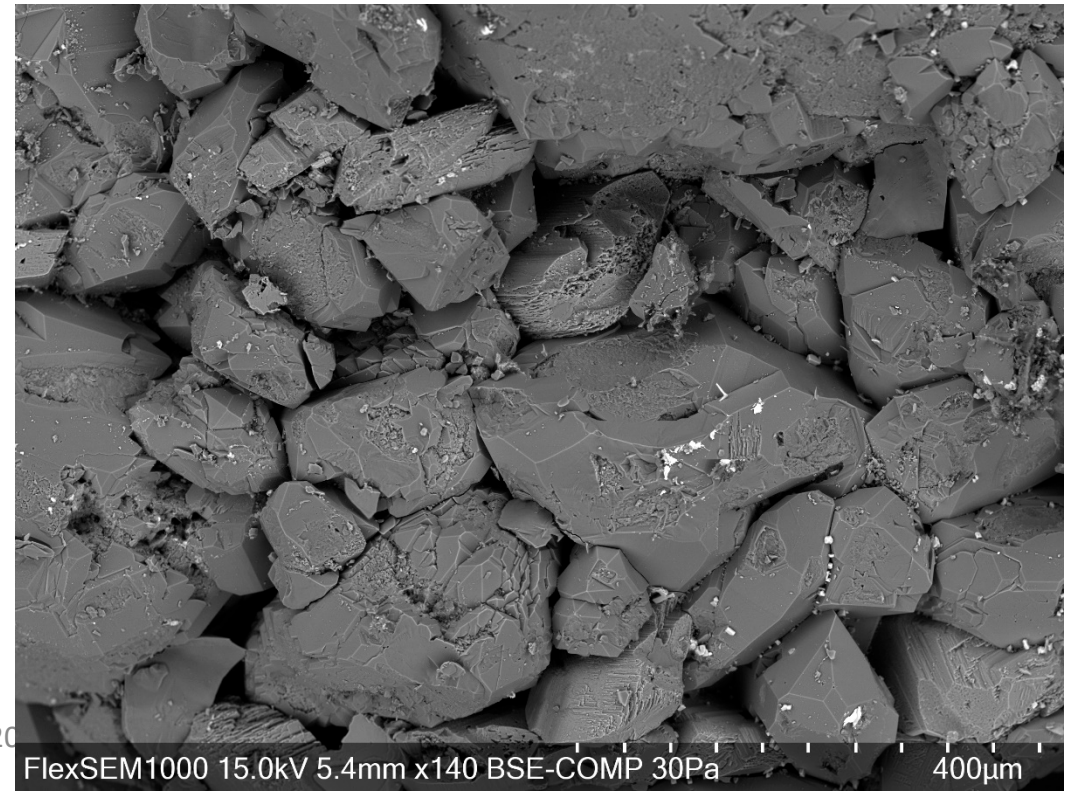


Tidal (Upper Mt. Simon)

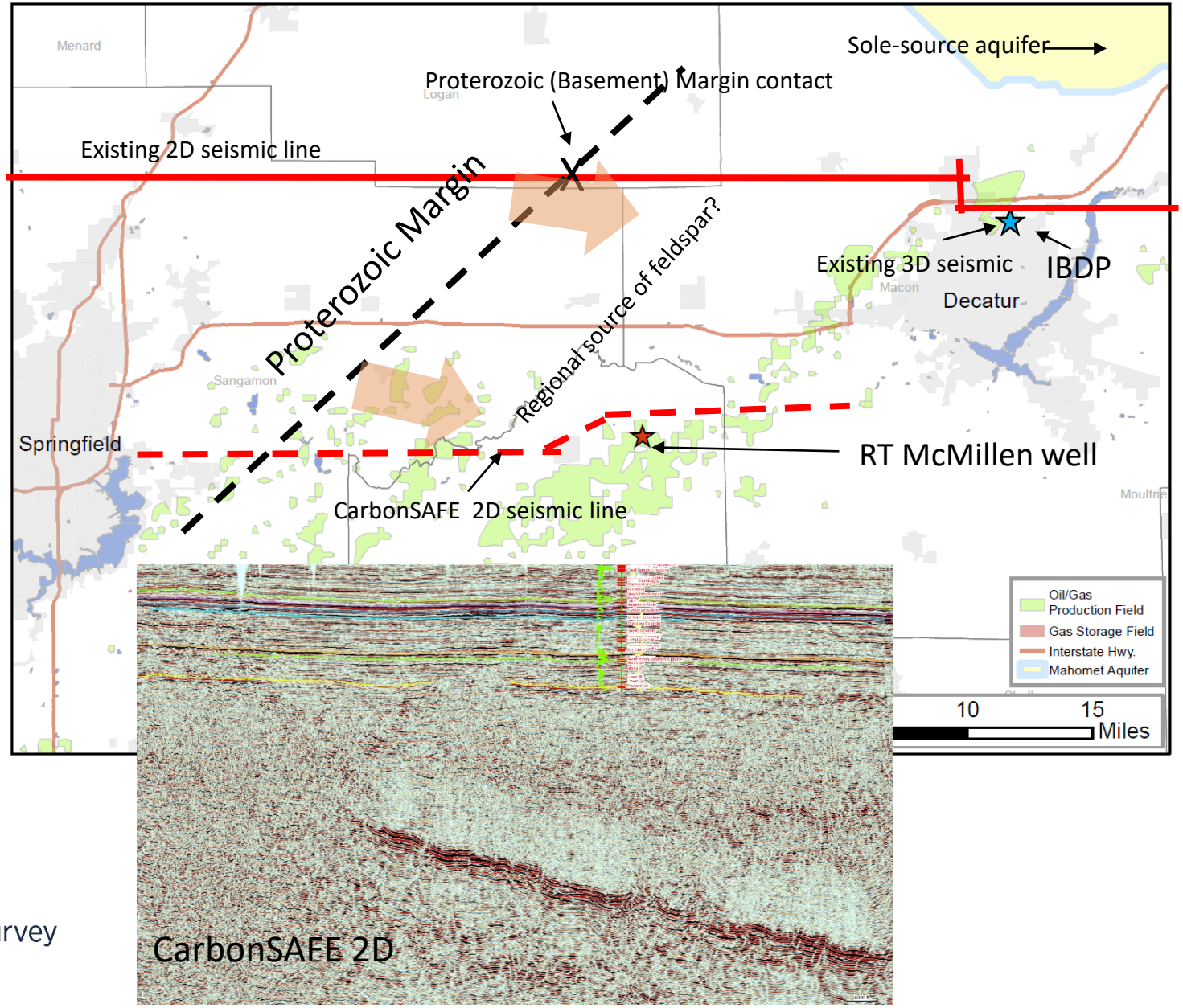


Bimodal, mature grains. Pores are generally small due to fine grains and/or abundant quartz/feldspar cement

All grains (including feldspars) have authigenic cement overgrowths



Geological Controls over Storage Complex Distribution



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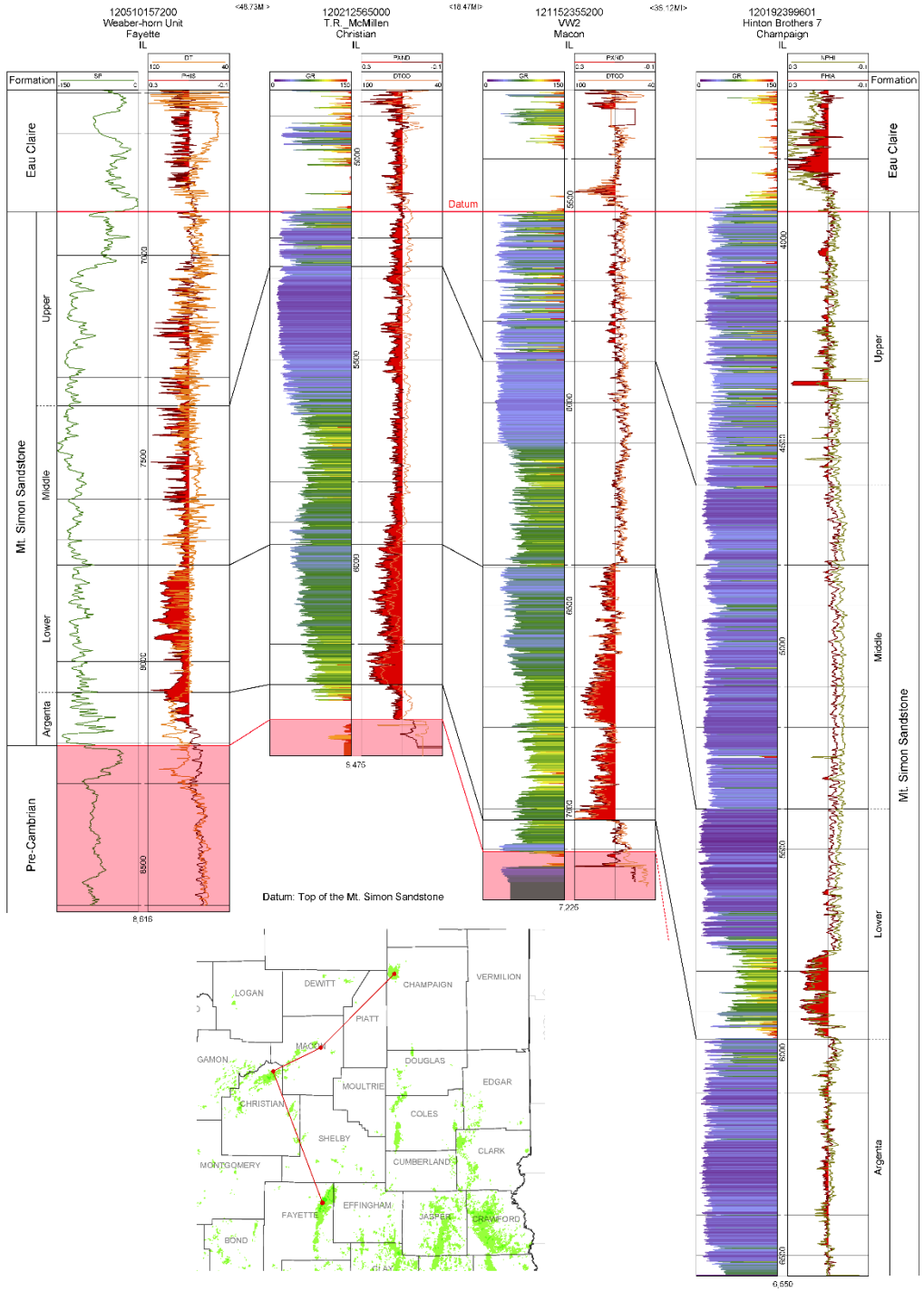
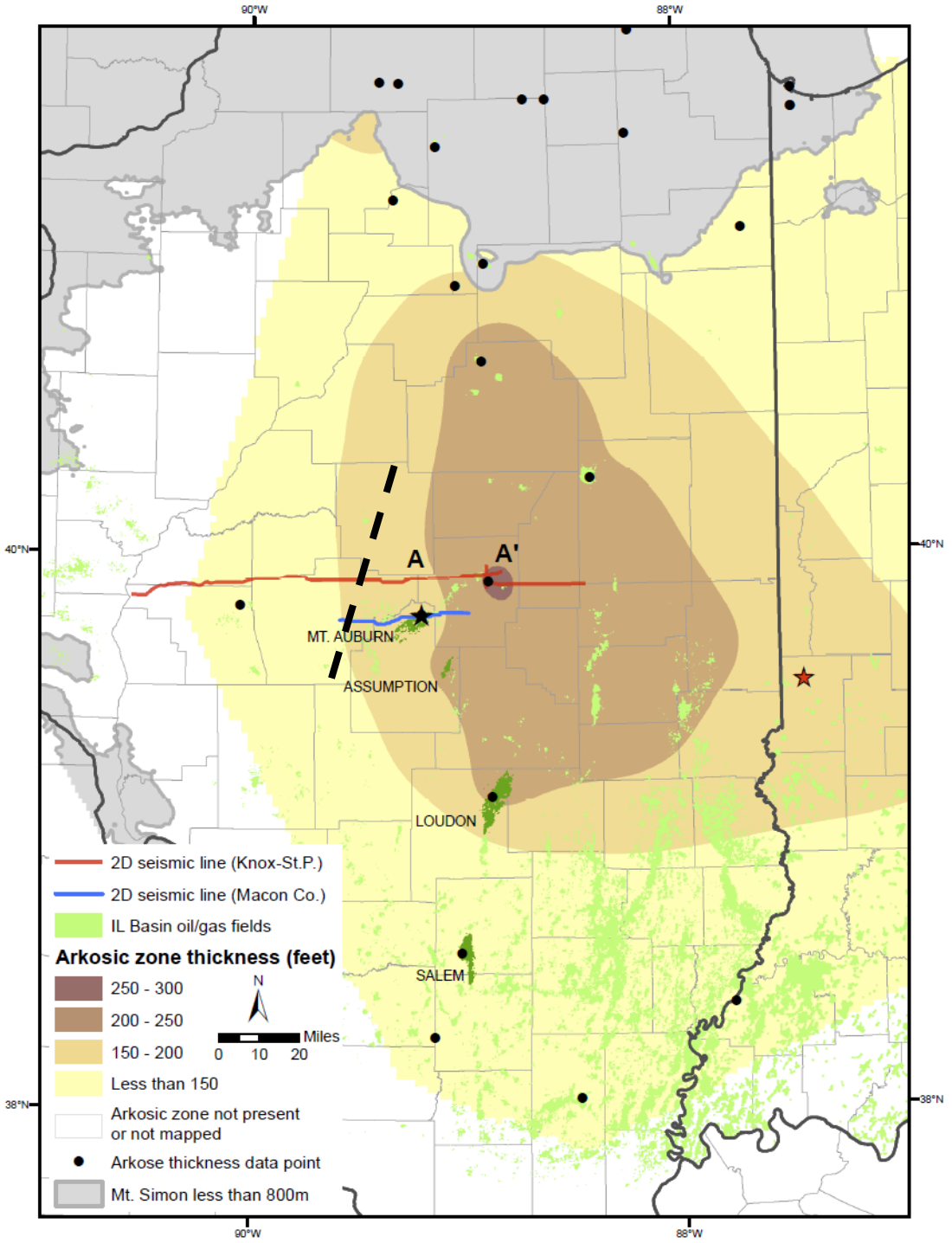
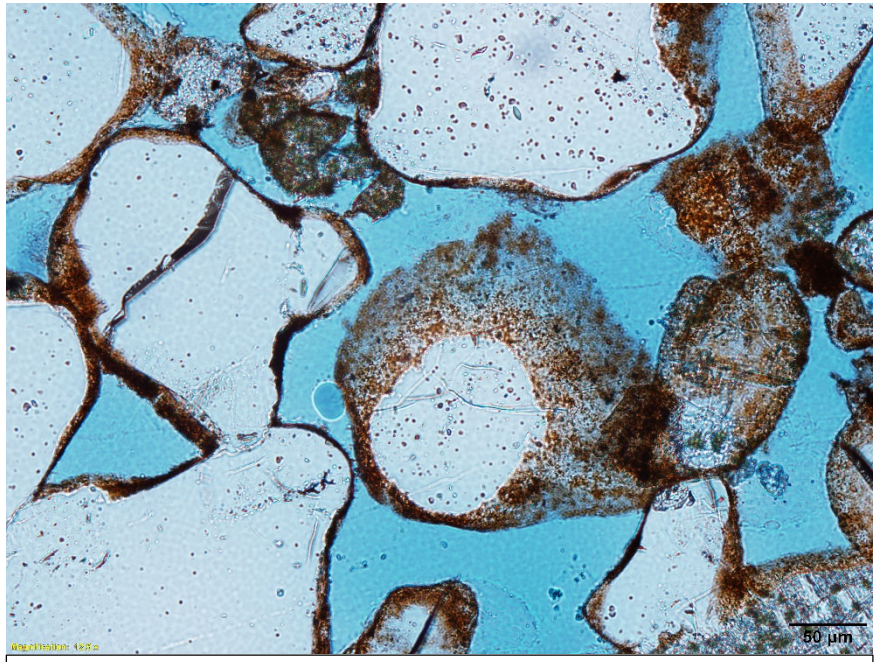

120510157200
Weaber-horn Unit
Fayette
IL
120212565000
T.R._McMillen
Christian
IL
121152355200
VW2
Macon
IL
120192399601
Hinton Brothers 7
Champaign
IL
Formation
Eau Claire
Mt. Simon Sandstone
Upper
Middle
Lower
Argenta
Pre-Cambrian
Datum
Datum: Top of the Mt. Simon Sandstone
LOGAN
DEWITT
CHAMPAIGN
VERMILION
PIATT
MACON
GAMON
DOUGLAS
EDGAR
MOULTRIE
CHRISTIAN
COLES
SHELBY
CLARK
MONTGOMERY
CUMBERLAND
EFFINGHAM
FAYETTE
JASPER
CRAWFORD
BOND

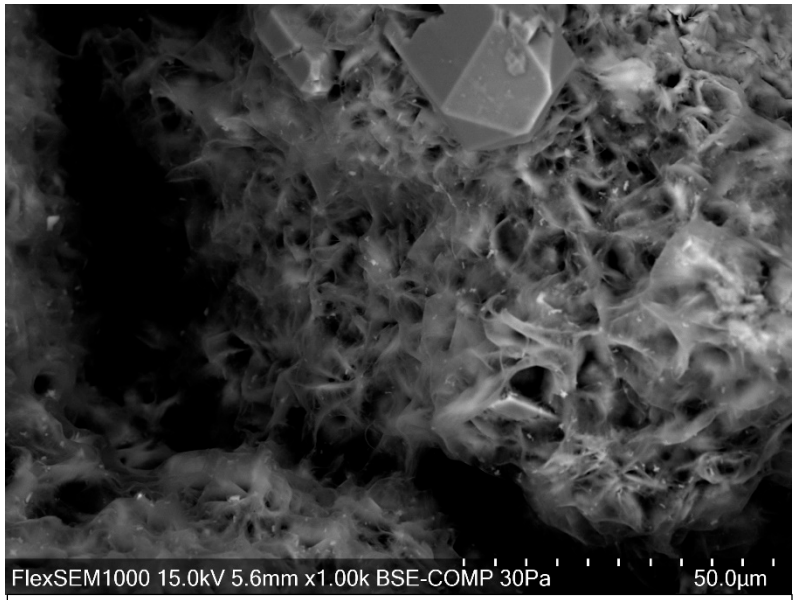

90°W
88°W
40°N
38°N
A
A'
MT. AUBURN
ASSUMPTION
LOUDON
SALEM
2D seismic line (Knox-St.P.)
2D seismic line (Macon Co.)
IL Basin oil/gas fields
Arkosic zone thickness (feet)
250 - 300
200 - 250
150 - 200
Less than 150
Arkosic zone not present
or not mapped
Arkose thickness data point
Mt. Simon less than 800m
N
Miles
0 10 20

Diagenesis of the Mt. Simon and Pore Space Paragenesis

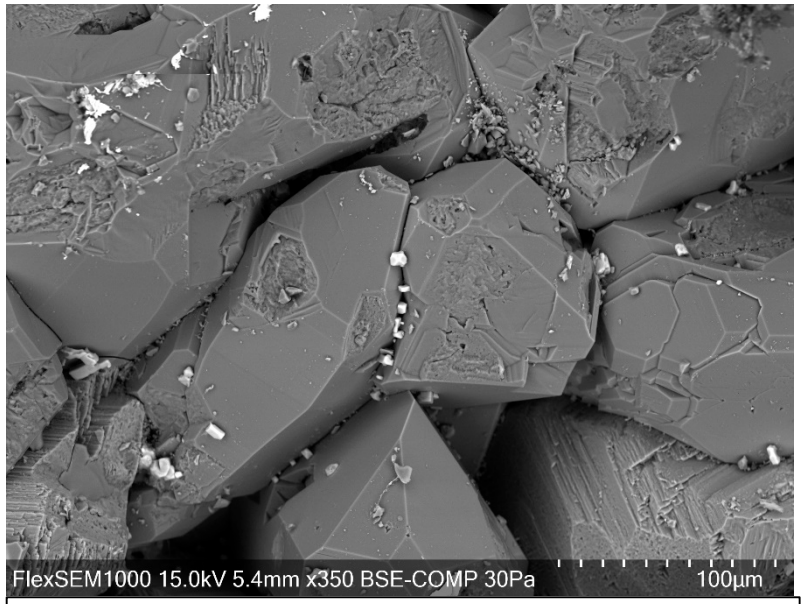
Most grains have early clay coatings



Clay coatings prevent the nucleation of major authigenic quartz overgrowths



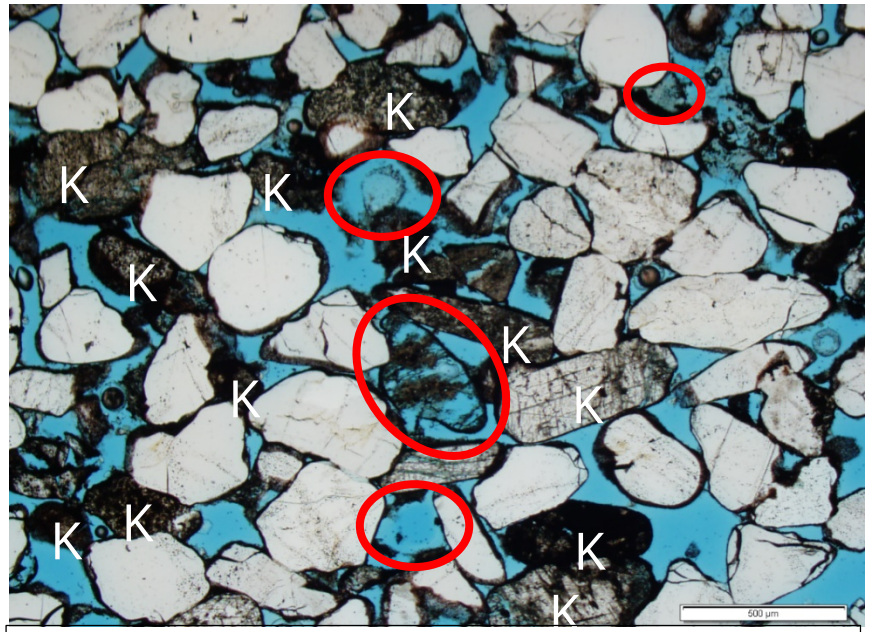
Grains coated in illite. Illite is webby and nucleation points on quartz grains are small. Thus authigenic quartz crystals are small but act as a cement to prevent extensive compaction preserving primary porosity.



When clay coating are absent, entire surface of quartz grains acts as nucleation point and large quartz overgrowths nucleate and close up pore space

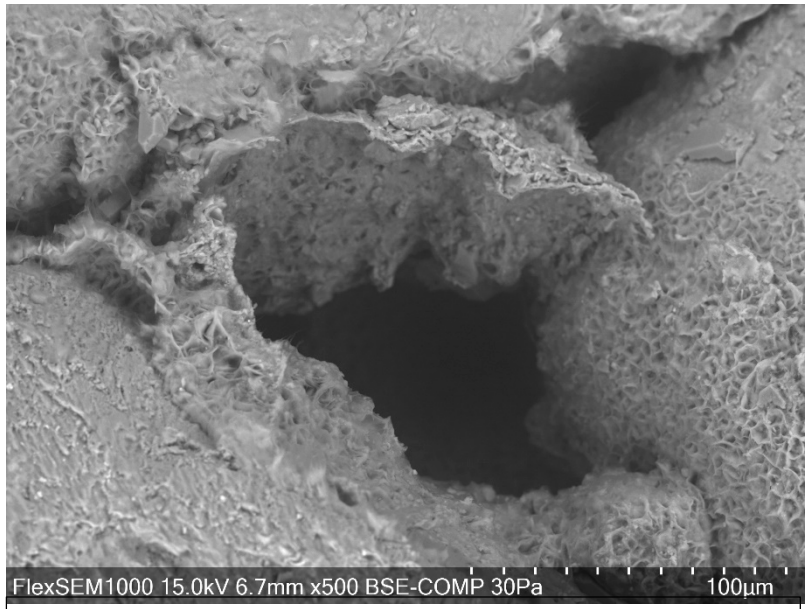
Diagenesis of the Mt. Simon and Pore Space Paragenesis

Another major contributor to porosity in the Mt. Simon is secondary porosity



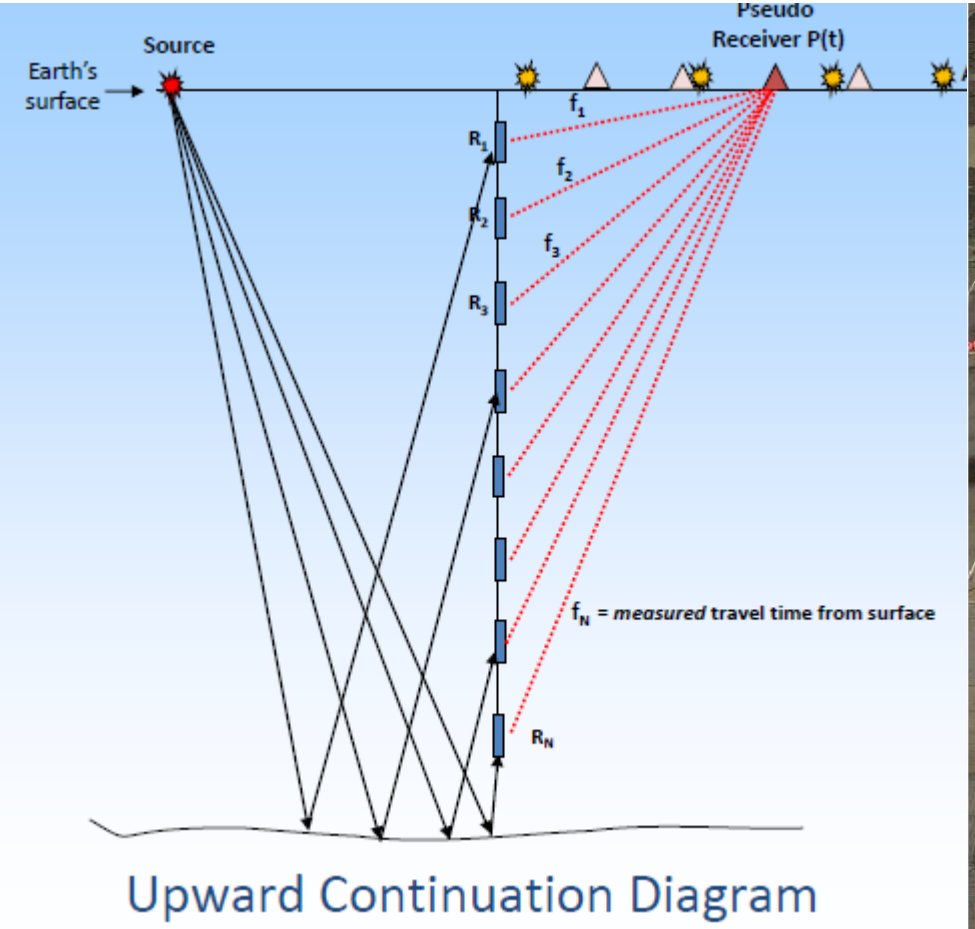
Feldspar dissolution is a late stage event and is a major contributor to porosity

Partial dissolution of feldspar



Complete dissolution of feldspar with clay cast and large secondary pore

Reservoir Characterization: Vertical Seismic Profiles

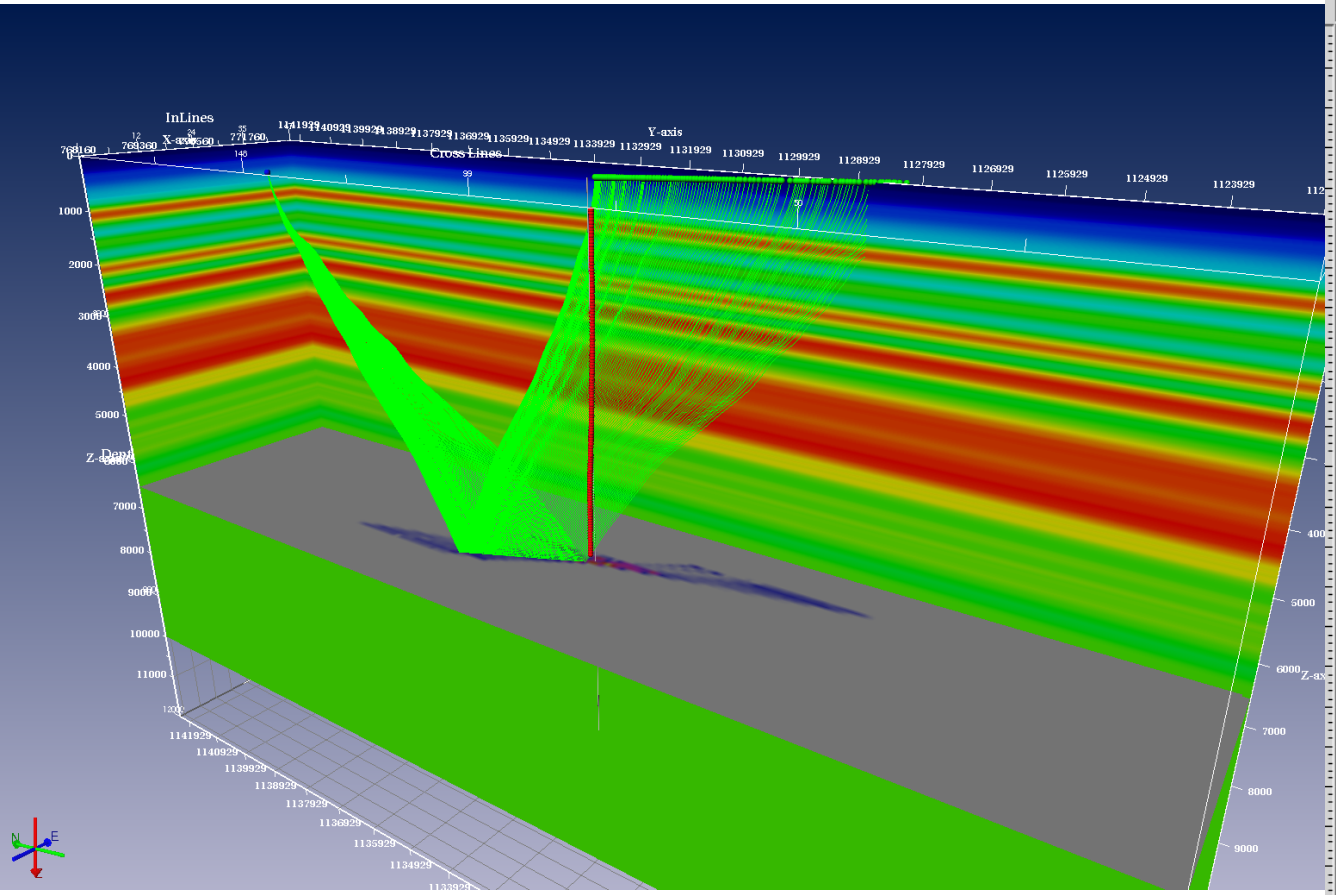


Upward Continuation Diagram

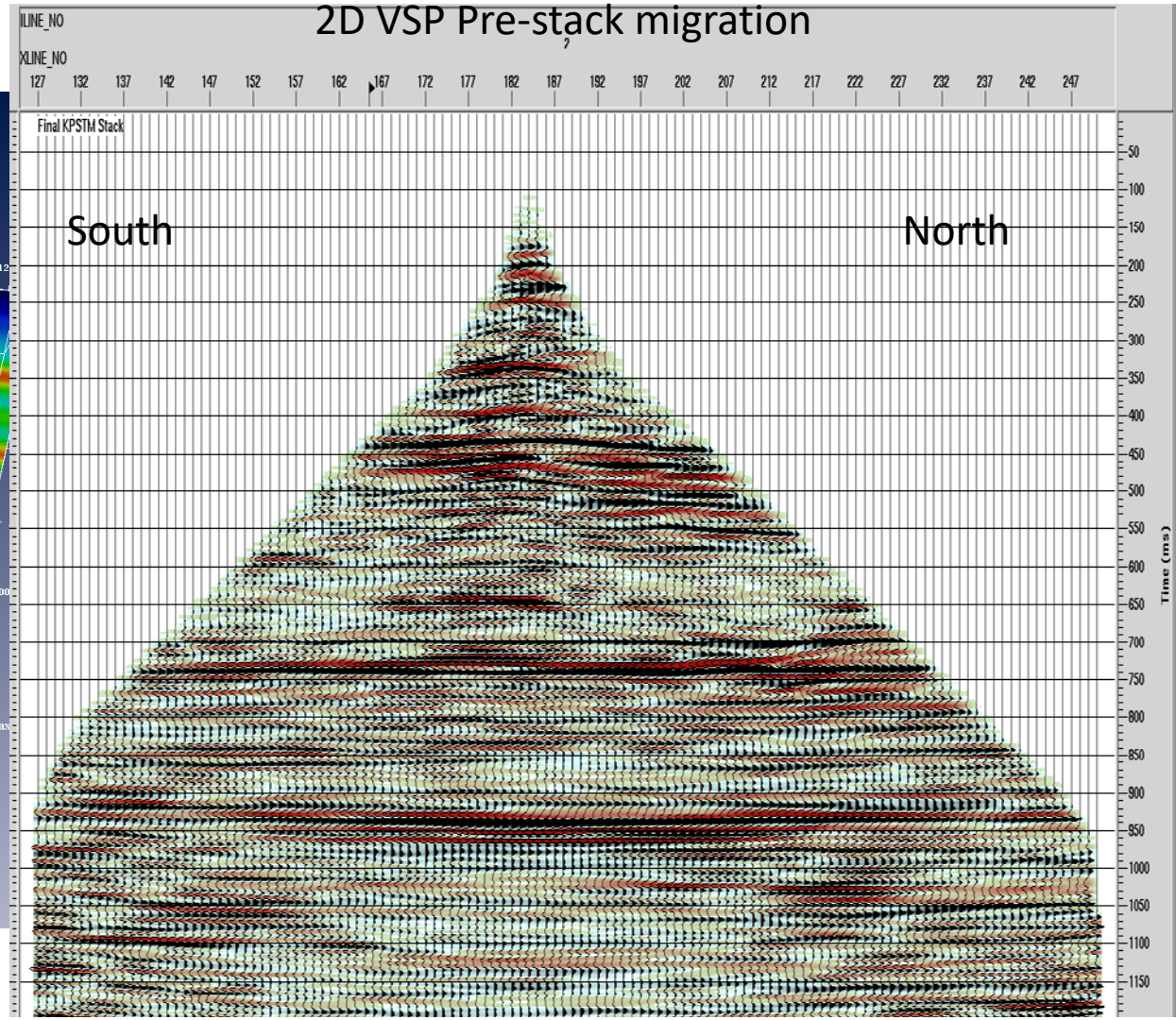
- One zero-offset
- One walk-away 2D VSP

Reservoir Characterization: VSP

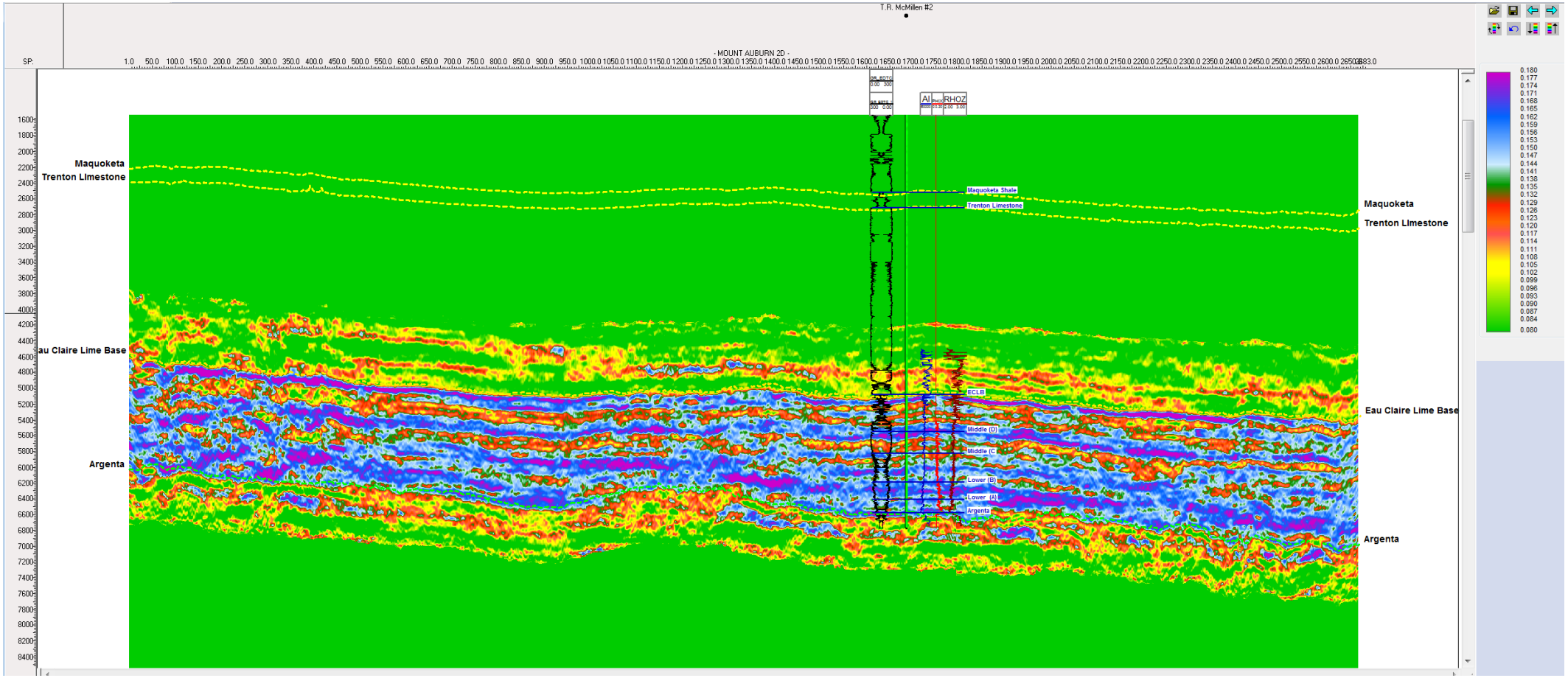
Ray Traces

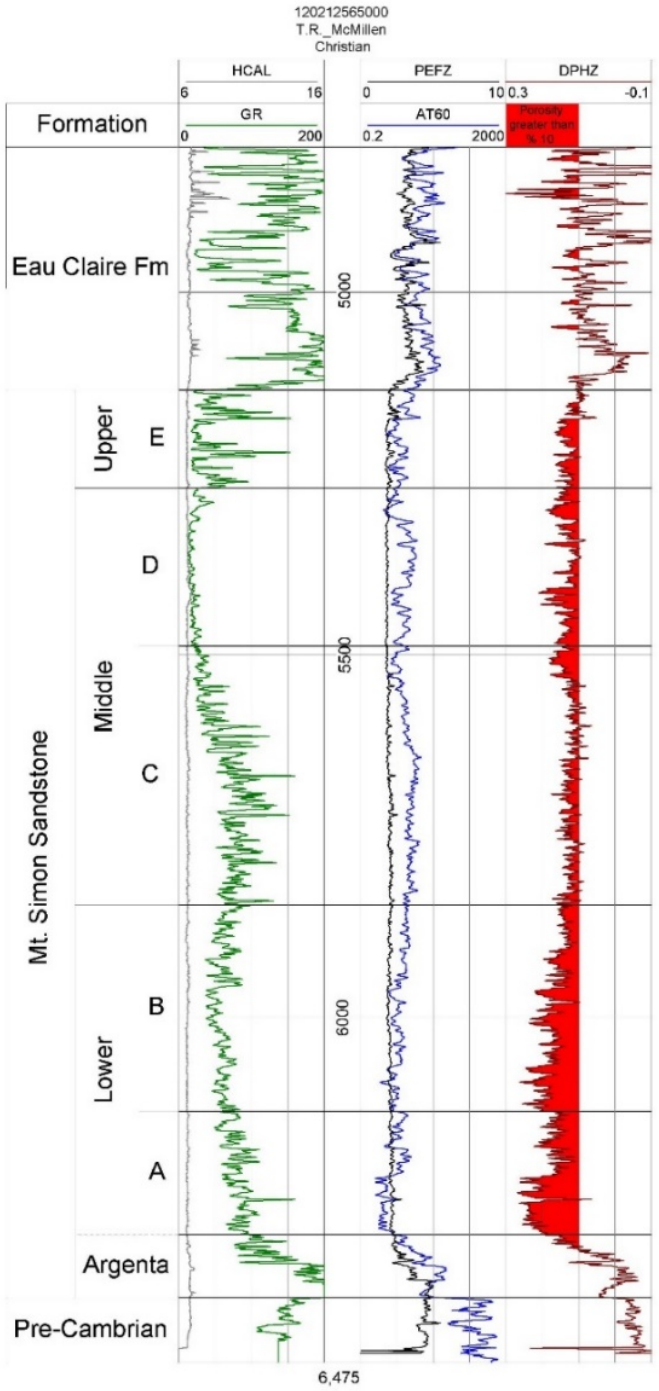


2D VSP Pre-stack migration



Reservoir Characterization:
Porosity 2D Seismic Line - inversion





Reservoir Characterization: Single well, multilayer tests

Injection Tests

Step rate test and pressure falloff

↕ Vertical Interference

Step rate test

Single Well, Multilayer Tests

Step rate test

↕ Vertical Interference

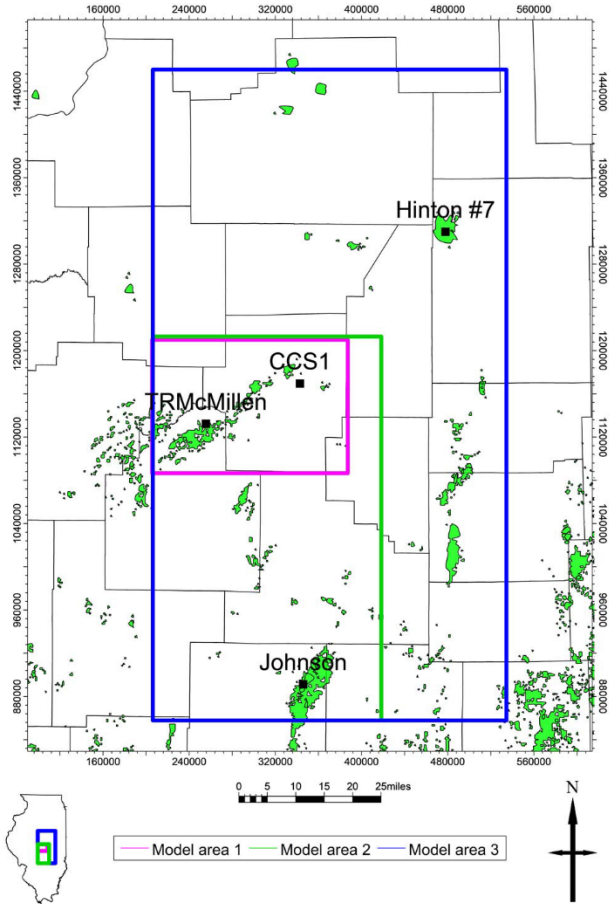
Step rate test

↕ Vertical Interference

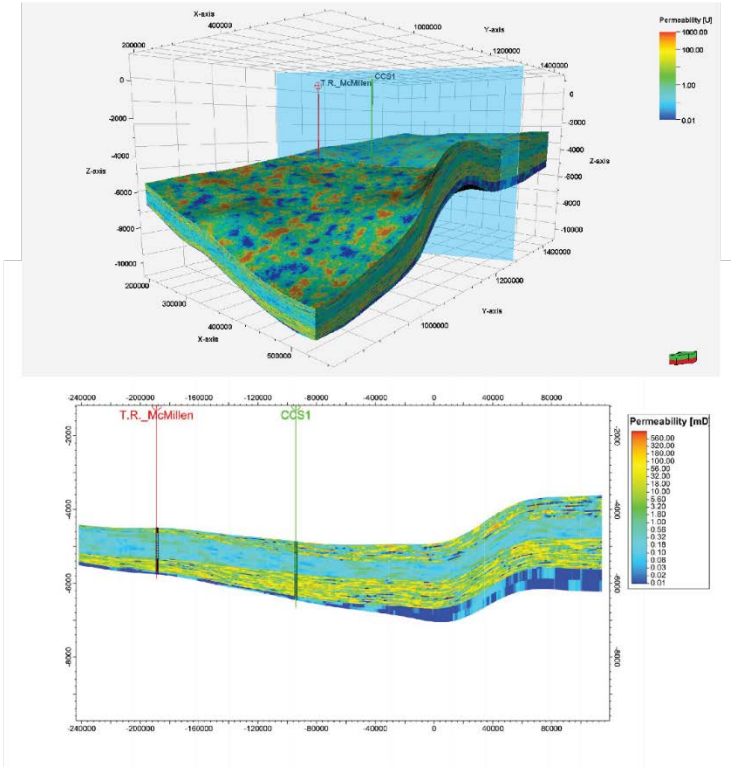
Step rate test

Pump (production) tests

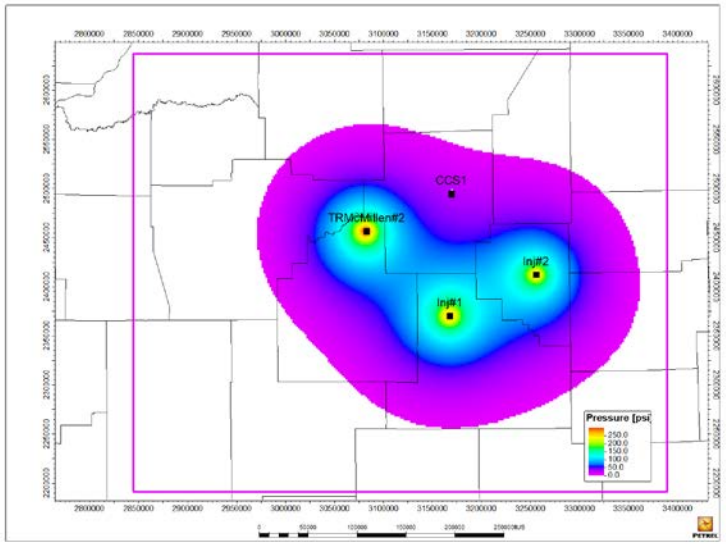
- **Reservoir Limit** (extended pump test), looks deep into reservoir – pore space
- **Deliverability** (multi-rate) Tests: max injection rates
- **Pressure Buildup**: perm and skin



Static



Dynamic



Modeling

CarbonSAFE Macon Achievements to Date

- Completed most of site data acquisition; analyses and interpretation ongoing
- NRAP tools
- Conceptual model for Mt Simon Storage Complex (regionally)
- Site specific characterization indicates high quality reservoir for CO_2 storage
- Preliminary analyses suggest site can accommodate >50 Mt CO_2 over 30 years
- Industry interest is high and multiple sources can exploit the Mt Simon Storage Complex in central Illinois

Appreciation to US DOE for supporting project DE-FE00029381

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